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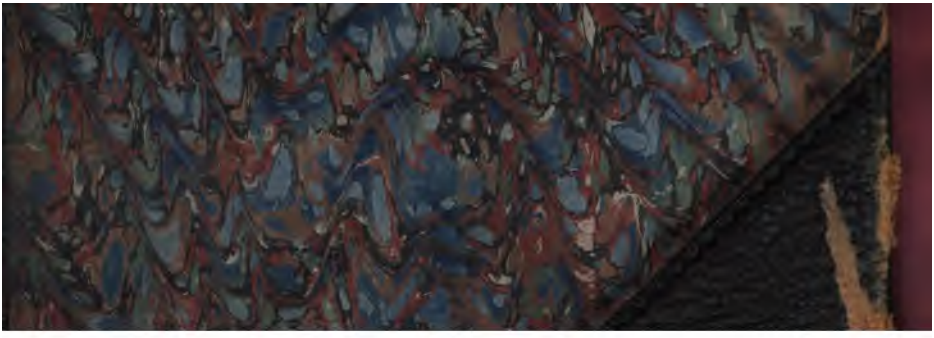

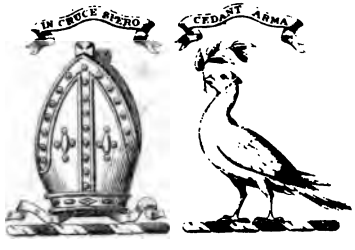

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CONTENTS.

PAGE

President's Address at the Opening of the Session 1873-74 . . i

On the Upper Greensand or Chloritic Marl of Cambridgeshire. By the Rev. T. G. Bonney, M.A., F.G.S., F.S.A. . . . 1

On the Geology of Hampstead, Middlesex. By Caleb Evans, Esq., F.G.S. (*With map*) 21

On a recently exposed Section at Battersea. By John A. Coombs, Esq. (*With four woodcuts*) 33

Visit to the Museum of Practical Geology 38

Excursion to Maidstone 38

Excavations on the Site of the New Law Courts. By Wilfred H. Hudleston, Esq., M.A., F.G.S., F.C.S., and F. G. Hilton Price, Esq., F.R.G.S., M.A.I. (*With plate and eight woodcuts*) 43

Excursion to Watford 65

Excursion to Hampstead 67

On a visit to the Diamond Fields of South Africa, with Notices of Geological Phenomena by the Wayside. By John Paterson, Esq., M.A. (*Abridged*) 70

On Columnar Basalts. By John Curry, Esq. (*Abstract*) . . 80

Excursion to Erith 83

Visit to the British Museum 86

Excursion to Bath. 89

Excursion to Guildford 93

On the Classification of the Cambrian and Silurian Rocks. By Henry Hicks, Esq., F.G.S. (*With a table and woodcut*) . 99

On the Silurian Rocks of the English Lake District. By Professor Alleyne Nicholson, M.D., D.Sc., M.A., F.R.S.E. . . 105

Excursion to Bromley and Chislehurst 114

Excursion to Hendon and Finchley 115

On Corbicula fluminalis, its Associates and Distribution in Britain. By Alfred Bell, Esq. (*Title only*) 117

On Specimens of Ptychodus latissimus from the Chalk of Grays, Essex. By Owen Rees, Esq., F.G.S. (*Abstract*) . . 11

On the Dip of Chalk in Norfolk, and the Remains of Old Land Surfaces called the Stone-Bed. By the Rev. John Gunn, M.A., F.G.S. (*With woodcut*) 117

Excursion to Walton-on-the-Naze 122

Visit to the International Exhibition 123

Excursion to Ludlow and the Longmynds 124

On the Influence of Geological Reasoning on other Branches of Knowledge. By Hyde Clarke, Esq., F.S.S., M.A.I. . . 129

PAGE.

On Coal Seams in the Permian at Ifton, Shropshire. By D. C. Davies, Esq., F.G.S. (*With plate of sections and woodcut*) . 138
On a Well Section at Finchley. By Caleb Evans, Esq., F.G.S. . 148
On the Cambrian and Silurian Rocks of Ramsey Island, St. David's. By Henry Hicks, Esq., F.G.S. 155
Annual General Meeting 157
On the Diprionidæ of the Moffat Shale. By Charles Lapworth, F.G.S. (*Abstract*) 165
On the Geology of Brighton. By James Howell, Esq. . . 168
Visit to the Botanical Department of the British Museum . . 189
Visit to the Museum of the Royal College of Surgeons . . 190
On the Origin and Present Position of the Diamonds of South Africa. By G. C. Cooper, Esq. (*Title only*) . . . 192
On some Fossils from the Margate Chalk. By John William Wetherell, Esq. (*With woodcut*) 192
Excursion to Banbury 197
Visit to the Museum of Practical Geology 205
Excursion to Charlton 205
On the Valley of the Vézère, Périgord, its Limestones, Caves, and Pre-historic Remains. By Professor T. Rupert Jones, F.R.S., F.G.S. 207
Excursion to Aylesbury. 210
Excursion to Eastbourne and St. Leonards 211
Excursion to Finchley 214
On Ammonite Zones in the Isle of Thanet. By Francis Alfred Bedwell, Esq., M.A., F.R.M.S. (*With plate*) . . . 217
Excursion to Brighton 239
Excursion to Hatfield 240
Sketch of the Geology of Northamptonshire. By Samuel Sharp, Esq., F.S.A., F.G.S. (*With two woodcuts*) 243
An Account of the Eruption of Mount Vesuvius, of April, 1872 253
On some New Crag Fossils. By Alfred Bell, Esq. (*Title only*) . 265
Excursion to Plumstead and Crossness 265
Excursion to Malvern 269
Opening Meeting of Session 1873-4 281
The Yorkshire Oolites. By Wilfrid H. Hudleston, Esq., M.A., F.G.S., &c. (*with eight woodcuts*) 283
Summary of the proceedings of the Geologists' Association during the year 1873 334
On the Nature and Formation of Flint and Allied Bodies. By M. Hawkins Johnson, Esq., F.G.S. (*Title only*) . . . 335
On the Origin and Present Position of the Diamonds of South Africa. By G. C. Cooper, Esq. (*With two woodcuts*) . 336
Annual General Meeting 344
Index 353

LIST OF ILLUSTRATIONS.

		PAGE
1.	Plate I.—Geological Map of Hampstead . . Opposite	21
2.	Section at Battersea	34
3.	Section showing False Bedding at Battersea . . .	34
4.	Section of False Bedded Sand with Oxyde of Manganese at Battersea	34
5.	Section showing lines of Black Gravel at Battersea . .	35
6.	Section at Bell Yard, Fleet Street	46
7.	Section near the Strand	48
8.	Section at Clement's Inn	49
9.	Section at Temple Bar	50
10.	Section near Carey Street	51
11.	Section near Clement's Inn	56
12.	Section near St. Clement Dane's Church	58
13.	Section showing Clay in Gravels, Law Courts Site . .	59
14.	Plate II.—New Species of Gasteropoda from the London Clay, Strand . . . . . Opposite	64
15.	Table of British Cambrian and Silurian Strata (1873) Opposite	99
16.	Section of Cambrian Rocks, St. David's, South Wales . .	102
17.	Section showing the Dip of the Chalk in Norfolk, and the Position of the "Stone Bed"	118
18.	Plate III.—Containing Sections of Upper Coal Measures, (supposed) Permian Marls, and super-imposed Coal Measures, along the strike of the strata on the North Wales Border . . . . . Opposite	140
19.	Section through Bryn-kinallt Pits, Pont-y-Blew Bridge, and Ifton Pits.	142
20.	General Vertical Section of the Margate Chalk . . .	193
21.	Plate IV.—Containing Outline Map of the Isle of Thanet. Cliff section from Birchington to Kingsgate. Cliff section from Kingsgate to Pegwell . . . . Opposite	225
22.	Section from Stamford, Lincolnshire, through Northampton-shire, nearly on the line of the Great North Road . .	245

23. Sections Illustrating the Relations of the Lincolnshire Limestone to the Northamptonshire Oolite 247
24. Section at Seamer Gap, Scarborough 287
25. Section from Peak to the Vale of York 290
26. Section at Blue Wyke Bay, Yorkshire 294
27. Section at Crag Hall, Yorkshire 294
28. Section at Crag Hall, Yorkshire 303
29. Section at Hundale, Yorkshire 312
30. Section at White Nab, Yorkshire 315
31. Section parallel to the Derwent Valley, Yorkshire . . 323
32. General section of South African Diamond Fields . . 336
33. Section of a South African Diamond Claim 338

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

ORDINARY MEETING, FEBRUARY 2ND, 1872.

The Rev. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Geology of Oxford and the Valley of the Thames," by John Phillips, M.A., F.R.S., F.G.S., from George Potter, Esq., F.R.M.S.

"Defense des Colonies," Part iv., by Joachim Barrande, from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Trilobites," by Joachim Barrande, from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Journal of the London Institution," from that Institution.

"Abstract of Proceedings of the Geological Society," from that Society.

The following Paper was read :—

ON THE UPPER GREENSAND OR CHLORITIC MARL OF CAMBRIDGESHIRE.

BY the Rev. T. G. BONNEY, M.A., F.G.S., F.S.A., Fellow and Tutor of St. John's College, Cambridge.

Within a circle drawn with a radius of about fifteen miles from Cambridge as a centre, we find the following formations :—

1. Peats and Gravels, fluviatile and estuarine ; belonging to the various periods posterior to the Glacial Epoch.
2. Boulder Clay.
3. Upper Chalk with flints.
4. Lower Chalk without flints, becoming marly at base.

5. Upper Greensand or Chloritic Marl.
6. Gault.
7. Neocomian.
8. Kimmeridge Clay.
9. Coral Rag (?)
10. Oxford Clay (with Elsworth Rock).

The strike of the beds, excepting the superficial deposits, is in a general north-east to south-west direction; their outcrop, owing to denudation, follows a much less regular course.

Cambridge itself is situated very near to the true junction of the Gault and Upper Greensand, in an irregular open and shallow valley. This is bounded on the one hand by the escarpment of the great Chalk plateau, which stretches away to the eastward until, on approaching the shore of the German Ocean, it disappears under the London Clay and later Tertiaries of Suffolk and Essex; and on the other by irregular outliers of Lower Chalk, or the accidental watersheds of a low table land composed of Gault or old gravel. About three miles above Cambridge, two small streams, coming respectively from the south-west and south-east unite, and are shortly after joined by a third from the west, thus forming the Cam or Granta. It would be beside the mark to discuss on the present occasion how the valley of the Cam and its tributaries has been excavated; suffice it to say, that in all probability this, to a considerable extent, existed prior to the Glacial period; but that it no doubt has been enlarged—perhaps greatly—by the action of the sea, as well as by the corroding action of the rain, streams, and frost. A glance at the map shows that the two first named streams have for some distance cut their way down to the Gault, while the last, as well as the main stream, flows wholly on that deposit; which, however, in the neighbourhood of Cambridge is covered up by beds of gravel several feet in thickness, which have been deposited by the ancient Cam. We have then on the right bank of the Cam, near Cambridge, the following general section:—

1. The Cam flowing over Gault through a low alluvial plain; this is some four or five feet above the mean level of the stream, consisting of a peaty clay, evidently river mud, which is often full of the ordinary fluviatile shells.

2. One or more indistinct terraces of river gravel; probably—though it is hard to distinguish them—belonging to different periods in an epoch of considerable duration. In these gravels are found the bones of extinct mammals, such as *Elephas primigenius*, and in the older deposits *Unio, littoralis* and *Cyrena (Corbicula) fluminalis*.
3. A low plateau, thirty or more feet above the Cam, and often a mile or two in width, formed by the softer beds of the Chalk Marl.
4. The escarpment of the Lower Chalk, which descends rather steeply to the Chalk Marl plain, and shows, nearly at the junction, a browner and sandier bed, which may remind us of the Totternhoe-stone of Bedfordshire.

At the bottom of this Chalk Marl, and passing insensibly into it but resting on an eroded surface of Gault, is a stratum, barely a foot in thickness, which is full of green grains and black granules and nodules, looking like a sediment from the purer marl above. The green grains are glauconite, the black nodules phosphate of lime, often but erroneously called *coprolites;* and this thin seam, which, however, is very persistent for many miles of country, represents the great development of the Firestone or Upper Greensand of the Isle of Wight, and possibly more than this. The abundance of these black nodules and their richness in phosphoric acid has caused the search after them to be a very profitable branch of industry. As much as £100 per acre has been paid for the privilege of digging for them; formerly it used to be said that the work did not pay if the depth of the nodules exceeded 12 feet, but of late years I have seen workings which went at least a yard deeper. The mode of proceeding is to dig a trench, with one face vertical, down to the nodule bed, to undermine this cliff, and then by driving wedges and crowbars along a line cut parallel to the edge of the cliff and some four feet from it, to split off a great slice of marl, and expose the stratum below.

The marly seam, in which are embedded the glauconitic grains and the phosphatic nodules, is then dug out and taken to a mill erected on the workings, where the mud is washed out, and the nodules are left behind, mixed perhaps with a little glauconite and a few larger stones.

So free, however, is this bed from admixture with pebbles of

other rock, that practically no hand picking is required. The nodules thus cleansed are conveyed away by barge or train to chemical works, where, after various treatments, the phosphate is prepared finally for use by the action of sulphuric acid on the compost.

As I have said, this seam, though not well exposed in any natural sections, can be found near the base of the Chalk escarpment for several miles on the right bank of the Cam,* and is, or has been, worked quite close to the Newmarket entrance to Cambridge. It then disappears under a cap of gravel, on which, or on the subjacent Gault, most of the town stands; but it has lately been again worked to the south of the town, a little beyond the Botanic Gardens, and it then runs, though concealed by gravel or soil, roughly parallel to the river for more than two miles. Here its outcrop recedes up into the Chalk plateau by ascending the beds of the above-named streams, and skirting an irregular but rather high promontory between two of these tributaries. On the opposite bank of the Cam are two considerable outliers; the one on which the old Roman town of Cambridge stood—for here, as not unfrequently has happened, the burghers have flowed out from the hill fortress to the lowlands across the stream, and have reared their richest buildings on the more roomy strath. This outlier is to a considerable extent covered with old river gravel, and must, in former times, have formed a marly shoal in the Cam estuary, with possibly a small chalky hummock sometimes emerging from the waves. This hummock, elevated by digging the material from the sides and throwing it upon the top, now forms the curious tumulus of Castle Hill. The other outlier is an irregular island, the nearest point of which is about a mile from Cambridge, whose boundary has been traced on the eastern and parts of the northern and southern sides, but on the remaining side is quite lost to view under a thick capping of Boulder Clay.

I proceed now to describe the rock itself, in doing which I may direct your attention to a valuable paper, by Mr. Seeley, in the 3rd volume of the "Geological Magazine" (p. 302), which leaves little to be added to the facts of the case.

1. *The Matrix.*—This consists of a fine chalky mud, largely composed of Foraminifera, and minute fragments of organisms. Under a microscope of low power it appears a fine powdery mud,

* It has been worked at intervals from Soham to the south of Hitchin, not less than 50 miles in extent.

the component fragments of which can hardly be recognised. On dissolving it in hydrochloric acid a considerable insoluble residuum remains behind, consisting (besides the green grains) of an extremely fine, pale-buff mud.

2. *The Glauconite Grains.*—These small grains are abundant enough in the rock to give it a distinctly green tinge. They are also sometimes entangled or embedded in the phosphatic nodules. The following analysis has been made of this mineral by Professor Liveing.

Water	10·80
Si...	51·09
Al	9·00
Fe	19·54
Mg.	3·37
Ca.	0·30
Na.	3·56
K.	2.47
	100·13

This result agrees fairly well with some members in Dana's table of analysis (which shews that under this one name of *Glauconite* are grouped minerals which vary considerably in chemical composition), but it has a little more silica, and at least 2 per cent. more alumina than those which he quotes as from Cretaceous rocks. It is also noteworthy that the potash is in this specimen replaced by soda to an extent unknown in Dana's specimens; the maximum of soda present in any of them being 1·6 per cent. The maximum of potash is 12, but the usual proportion is from 5 to 7.

As was demonstrated by Ehrenberg, and has been since confirmed by many observers, glauconitic grains are often the casts of foraminifera; and it is well known that the process of infiltration with a glauconitic or pyroxenic mineral is still going on in the beds of existing seas, notably the Ægean. I have not, however, been able to satisfy myself that any of these green grains are casts of organisms. Under the microscope they have a rolled, granular appearance, something like that of dry bread pellets. Still it is possible that some at least may once have been casts, but have been since subjected to the action of the waves.

Mr. Seeley, who has made sections of these grains, states—"The larger ones have a few foraminifera scattered through them, the shells of which are often filled with a more transparent sub-

stance, probably the red silicate. Smaller grains sometimes only just invest one polythalamous shell, while the smaller fragments are often shapeless. In many grains there is no trace of structure." He thinks, however, and in that I quite concur, that they must be regarded as a local product, and one would not be surprised to find, on further examination, that some were casts of the larger Foraminifera.*

3. The dark phosphatic nodules are, as I have said, commonly called coprolites. It is almost needless to say that this is a misnomer. True coprolites, similar to those met with in the Chalk (which used to be called Xyloeido-coprolites, and popularly larch-cones), are indeed found though but rarely.

The following is Dr. Völker's analysis of the phosphatic nodules, as quoted by Mr. Seeley:—

Moisture and organic matter...	4·68
Lime	43·21
Magnesia...	1·12
Oxide of Iron	2·46
Alumina	1·36
Phosphoric acid...	25·29
Carbonic acid	6·66
Sulphuric acid	·76
Chloride of Sodium	·09
Potash	·32
Soda	·50
Insoluble silicious matter	8·64
Fluorine and loss	4·96

In size the nodules vary from mere grains up to three or four inches in the longer diameter, and they occasionally attain a greater size. Often they are irregular concretions, without any shape; not seldom they are rude tubes, or halves of tubes, made up of successive layers. The exterior, which frequently has a rolled appearance, is a dull olive black or brown; the interior is generally rather paler and more distinctly brown, but sometimes is even grey. The fracture is earthy, like that of the finest marl; fish scales and small shells are occasionally found in them.

We come now to the fossil contents of this phosphatic bed. These, it must be premised, though abundant, are in many respects

* Since the above was written, this has been proved by Mr. Sollas, Quart. Journ. Geol. Soc., vol. xxviii, p. 397, who, by examining specimens which had not been separated out by acid (as mine had been), detected traces of the foraminiferal tests.

not in good condition. The bones of the more highly organised animals are often rolled and broken ; they usually occur singly, and genuine associated series of any number are very rare. Frequently they are overgrown with ostreæ and plicatulæ. Many of the shells also only exist in the form of casts, and these often are more or less broken ; they, too, not unfrequently support plicatulæ, &c. The collector, therefore, must not expect to obtain specimens to compare in beauty with those from Warminster or Blackdown ; moreover, the silver hammer must be largely employed in collecting, as the best fossils are only to be discovered when the stuff is washed, and are then picked out by the workmen.

The bones found in the bed are generally mineralized with phosphate of lime, and many of the mollusks are preserved simply as more or less perfect casts in the same material as the amorphous nodules ; small shapeless lumps may often be observed partly accumulated round or sticking to the larger fossils. Leaving for the present further discussion of the probable mode of formation of these nodules, which will be more conveniently considered after mention of the fossils which accompany or are preserved by them, I pass on to say a few words of the extraneous rocks found in the bed. These are not very unfrequent, and often of considerable size. Sometimes they are rounded, but more frequently subangular, the angles occasionally being sharp. It is evident that they lay for some time on the bottom of the sea, for many of them are covered with *Plicatula sigillina* and an ostrea. These are valuable as seals of genuineness, for erratics are common enough in the Drift which often caps the Greensand. In size the blocks vary from about an inch to a foot cube. We find among them light-coloured granite—sometimes quite rotten,—micaceous sandstone, with numerous small garnets, hornstones, and slaty rocks, quartzites, gneiss, mica and chlorite schists, traps, and rolled sandstones. Pebbles of obsidian sometimes occur. Mr. Seeley remarks that the slaty metamorphic rocks are less worn than the granites. He further states that he has seen no indubitably genuine specimen which had a trace of fossils.* I have, however, a fine Carboniferous Limestone coral, which I have every reason to believe

* He has since stated that he has found joints of *Poteriocrinus*. Since the above was written, a paper has been published by my friends Messrs. Jukes-Browne and Sollas on these erratics, Quart. Journ. Geol. Soc., vol. xxix., p. 11. I quite agree with them, except that I am not satisfied that they have found true glacial "striations" on any specimen.

came out of the Greensand. Balls of a vegetable resin are not rare, and I have seen a specimen that has been bored by lithodomi. The discussion of the physical significance of these erratics, I postpone for the present.

We have as yet found no remains of Mammalia in our Greensand. Of Aves, the Museum Catalogue includes 47 specimens, fragments—usually the ends—of bones. Mr. Seeley has at present referred them to two species (*Barretti* and *Sedgwicki*) of the genus *Eanliornis*. The bird itself was about the size of a gull. In the class, however, which Mr. Seeley considers a group of equal value with the birds as a link between the reptiles and mammals, the Pterodactyles, or Ornithosauria, our deposit is peculiarly rich. In his most valuable catalogue of the Ornithosauria, Aves and Reptilia, from the Secondary strata, in the Woodwardian Museum, we find 24 species enumerated, which he proposes to refer to two new genera—*Ptenodactylus*, which receives 21 of them, and *Ornithocheirus*. In his monograph he adds at least two species to the list, but hesitates about the generic division. Compared with the representative of this class, which had been previously revealed to us by the lithographic slate of Solenhofen, our Cambridge Ornithosauria are veritable giants. Mr. Seeley estimates, from a measurement of the bones and fragments which remain, that the majority of them would have had an expanse of wing of about 10 feet, and a height (when standing in the position of a bird) to the crown of the head of about 2 feet. Of their habits Mr. Seeley says :—" That they lived exclusively upon land and in air is improbable. It is likely that they haunted the sea-shores, and while sometimes rowing themselves over the water with their powerful wings used the wing membrane, as does the bat, to enclose their prey and bring it to the mouth. But the superior development of the pneumatic foramina suggests that their activity was greater than in ordinary sea-birds. The large Cambridge Pterodactyles probably pursued a more substantial prey than dragon-flies. Their teeth are well suited for fish, but probably fowl and small mammals, and even fruits, made a variety in their food." He thinks that in all probability they were covered with a filamentous downy feather or hair, like a bat's, and that they may have reproduced their species as do the birds.

The Deinosauria are represented by four species, and probably two genera—the principal being *Acanthopholis*—a reptile first de-

scribed by Professor Huxley, from the Chalk Marl of Folkestone, which had dermal armour and peculiar triangular serrated teeth. There are five species of *Ichthyosaurus*, including the well-known *I. campylodon*. One crocodile, 12 *Plesiosauri*, at least three *Stereosauri*, 1 *Polyptyctodon*. Of Chelonians, there are 19 species, belonging to four genera: *Rhinochelys*, *Emys*, *Trachydermochelys*, *Testudo*, 16 of them being referred by Mr. Seeley to the first-named, of which *Chelone pulchriceps*, Owen, is taken as the type. Of these reptilia the remains of *Ichthyosaurus* are common, teeth and vertebræ being most abundant; associated bones are rare. The Plesiosaurs appear to have been also abundant. Their remains are for the most part vertebræ and the great bones of the limbs, no part of the skull is found, except the basi-occipital bone (Seeley). The teeth (unquestionable) are very rare. The large striated teeth of *Polyptychodon*, often 3 or 4 inches in length, are not uncommon, but comparatively few bones of this saurian have been identified. The bones of chelonians, though generally in a rather broken state, are not unfrequently met with; separate mandibles are not uncommon, but perfect skulls are rare. Some of these must have quite rivalled the ordinary *Chelone* in size; and one, of which the head and shaft of the humerus, and two associated carpal bones have been found, must have been a perfect giant.

Pisces.—This class is fairly represented, but the remains in general are very fragmentary. The teeth and vertebræ of *Otodus appendiculatus* are common, and well preserved. *Lamna* also is not rare, *Notidanus* and *Hybodus* (spines and teeth), much less common. *Corax* and *Spinax* rare. The teeth of *Pycnodus*, *Acrodus*, *Enchodus*, *Ptychodus*, have been found; the palates of the first being fairly preserved, and not very rare. *Sphenonchus* has been collected, and a considerable number of the great palates of *Plethodus*. The teeth and rostra of *Saurocephalus lanciformis* are rather common, especially the former, which are occasionally found in small fragments of the jaw. The chimæroid fishes are represented by mandibles of more than one species of *Edaphodon*, broken specimens being far from uncommon. Besides these are broken spines, possibly of *Ptychodus*, bones from the tail and head of fishes, and numerous fragments which have not yet been assigned to any known genus. Scales of *Lepidotus* are in the Woodwardian Collection, and those of several other fishes have been found, which at present are undetermined. They are occasionally aggregated.

Of the CEPHALOPODA, our Museum contains 4 species of Belemnites; *B. ultimus*, *B. minimus*, *B. semicaniculatus*, and *B. plenus*; the part preserved being little more than the guard, and that often waterworn. A specimen of *Conoteuthis* is also in our collection. Of *Nautilus* we have probably four or five species, three of which are named; the shell has always perished, and casts of separate chambers are not rare. The mandibles of the animal are occasionally found. The Ammonites are numerous, and 21 species have been described by Mr. Seeley in "The Annals and Mag. Nat. His.," 3 ser., vol. xvi., p. 225. Or, to speak more correctly, *varieties* of 3 great types, which are respectively represented by the species *A. rostratus*, *A. splendens*, and *A. planulatus*. The shell is not preserved, and they are often broken. They do not usually attain a large size, rarely exceeding about 2½ inches in diameter, but fragments of much larger individuals are occasionally found. *Scaphites æqualis* is not rare, but usually badly preserved. There are several species of *Turrilites*, existing only as broken casts, rarely exceeding the amount of three whorls. Only four have as yet been determined. We have several species of *Hamites*, one of *Helicoceras*, and at least one of *Baculites*; but these are generally in a very imperfect condition.

The GASTEROPODA exist almost always in the form of casts, a *Rostellaria*, *Solarium* (especially *ornatum*), some species of *Pleurotomaria*, *Dentalium*, and *Cinulia*, being among the commoner. *Pteroceras*, and *Natica*, are not rare genera. *Funis elongatus*, which is far from common, though broken, usually retains its shell. In all, about 25 genera are named in the Woodwardian Collection, but the Gasteropoda as a class are not numerically very abundant. *Natica*, *Solarium*, *Trochus*, *Pleurotomaria*, and *Cinulia* are most perfectly preserved; the long spiral shells like *Rostellaria*, are usually broken off after a whorl or two, and sometimes have a plicatula attached to the fractured end.

There are about 18 genera of LAMELLIBRANCHIATA. The genera most abundantly represented by individuals are *Ostrea* (4 sp.), *Exogyra* (3 sp.), *Avicula*, *Plicatula* (3 sp.), *Spondylus* (3 sp.), *Perna* (about 7 species). All but the last-named usually have the shell preserved. *Ostrea* and *Exogyra* often have the valve free from phosphate. There are 7 species of *Nucula* (casts), of which *N. simplex* is not uncommon. *N. ovata* is more rare. The most interesting member of this class is *Radiolites*, fragments of which

are not rare, though perfect specimens are difficult to obtain. There is a superb group of *R. Mortoni* in the Museum, consisting of two nearly perfect individuals, with a fragment of a third; the largest is full two feet long, and six inches in diameter.

Brachiopoda.—This class is represented by the genera *Terebratula*, *Rhynchonella*, *Terebratulina*, *Argiope*, and *Terebratella* (*Kingena*). The shells of these are often well preserved, those of *Rhynchonella* being the rarest, and those of *Terebratula* often being broken off in the washing. The well-known *Terebratula biplicata* is very abundant, having now absorbed all the varieties which once figured as distinct species. There are three species of *Rhynchonella*—*R. compressa*, *R. Mantelliana*, and *R. sulcata*, the last being commonest. *Terebratella lima* is fairly common, the tiny *Argiope decemcostata* rarer, and the beautiful little *Terebratulina gracilis* pretty common—the shells of the last two genera are usually empty.

Polyzoa.—We have a few polyzoa; but so far as my experience goes they are rare.

Crustacea.—The class Crustacea is well represented. Far the commonest is *Palæocorystes Stokesii;* the carapace is often well preserved, being filled with phosphate, but the limbs are rarely attached. Some specimens show by the external tumidity of the carapace that their branchial regions were infested by a parasite, probably a species of *Bopyrus*. *Necrocarcinus Bechii* is not uncommon; the other two species of this genus, *N. Woodwardii* and *N. tricarinatus* are rarer, *Eucorystes Carteri* and *Etyus Martini* are not uncommon, but *Xanthosia granulosa*, *Diaulax Carteriana*, *Cyphonotus incertus*, and *Hemioon Cunningtonii* are rare. Of the Macrurous Crustaceans, none of which are very common, we have *Hoploparia sulcirostris* and *H. scabra*, *Phlyctisoma tuberculatum*, and *P. granulatum*, and *Glyphæa cretacea*. *Squilla Maccoyii* and *Palæya Carteri*, *Scyllaridea cretacea*, and *Homolopsis Edwardsii* are very rare. The valves of small Entomostraca are common, and those of *Pollicipes* are not rare, and are always, so far as I remember, free from phosphate.

None of the Echinodermata can be called common. Broken spines and single plates of *Cidaris* are not rare, but specimens of the test at all perfect are very scarce. The heavy spine of *C. Dixoni* is occasionally found. *Pseudodiadema* is not unfrequent as a rolled cast; unworn or even unbroken tests are rare. There is more

than one species—how many is doubtful.* *Salenia* (*S. Woodwardii*) very scarce. Of the Echinoidea exocyclica all are rare. We have probably two species of *Discoidea*, one of *Galerites*, one of *Holaster*, and three of *Hemiaster;* these are very commonly casts. Of the Starfishes, fragments of two species of *Astrogonium* have been identified. The joints of a *Pentacrinus* are not very uncommon.

Of the CŒLENTERATA we have as casts *Smilotrochus elongatus* common, and *S. angulatus* not rare, also a cast of a depressed, cup-shaped coral with 48 well-developed septa, as yet unnamed. The corallum of *Micrabacia coronula* is not uncommon, perfect but small in size, and that of *Onchotrochus Carteri* is less frequent. There are some other corals not yet determined, also two or three species of *Isis*.

With regard to the class SPONGIDA, I cannot give much information. *Porospongia ocellata*, *Polypothecia infundibulum*, *Scyphia tessellata*, and two other species, and a *Chenendopora* have been identified. I think that I have recognised a *Siphonia*, and not a few of the phosphate nodules and casts shew traces of organisms which are probably ramose sponges.† The burrows of *Clione* are, I think, not unfrequent.

We come, then, in conclusion, to the FORAMINIFERA. These are very abundant in the chalky marl which is washed out of the matrix. *Globigerina*, *Cristellaria*, *Textularia*, *Nodosaria*, and other common forms, have been identified, and I have no doubt that there is here a most promising field of research for those who are blessed with good eyesight.‡ Our greatest object of interest among the Rhizopods is, however, the large arenaceous foraminifer, *Parkeria*, which is almost confined to our neighbourhood. Time does not allow me to do more than to refer you to Dr. Carpenter's monograph and magnificent plates, "Philosophical Transactions," 1869, p. 721, and I will merely call your attention to three points—First, that,

* Dr. Wright considers *P. Carteri* = *P. ornatum;* the latter is the commonest species.—"Cretaceous Echinodermata," p. 105 (Palæontographical Society).

† Mr. O. Fisher at one time considered most of the coprolites phosphatized Alcyonaria; this opinion he has since modified. Mr. Sollas refers them to sponges, Quart. Journ. Geol. Soc., vol. xxix., p. 52, 63. They have, at any rate, demonstrated that the nodules very commonly have an organic origin, and the latter gentleman has succeeded in identifying several of the sponges, among them *Ventriculites* (*id.* p. 76). Their papers have all been published since the above was written. I am glad of the opportunity of bearing testimony to the value of their labours, especially in the case of the latter gentleman.

‡ Since the above was written Mr. Sollas has identified several genera. Quart. Journ. Geol. Soc., vol. xxviii., p. 397.

excepting *Eozoon*, it is the largest known foraminifer; being commonly from ½in. to 1½in. in diameter, and occasionally more than 2in.; secondly, that there are at the very least three remarkable types, varietal or probably specific; one the ordinary nearly spherical form, another flattened and rather mushroom-shaped, and the third spherical but with large blunt prominences, faintly reminding us of the aspect of *Calcarina;* and lastly, that the principal part of sand grains of which the test is constructed are *phosphate of lime.**

Two questions now remain for discussion—

1. The question: do the fossil contents of this deposit represent more than one geological epoch in the ordinary acceptation of the term? That is, does the bed contain an Upper Greensand fauna only, or does it, together with this, contain a certain number of derived fossils? And
2. Does it throw any light on the physical geography of the country during the Cretaceous Period?

In considering the first question, we may put out of sight the very few instances where fossils have occurred from beds older than the Gault, and consider how far this thin noduliferous seam can be held to represent a mixture of Upper Greensand fossils with those that have originally been entombed in the Gault clay.

Now, to return to the stratigraphical position of this deposit, we find that it generally graduates almost imperceptibly into the marly Chalk above, but rests with a well-defined boundary on the subjacent Gault clay. Again, on examining the fossils one cannot fail to notice that the majority of the bones are much broken and rolled, are mineralised by a dark phosphate, and have small plicatulæ, spondyli and ostreæ attached; while the rest are paler in colour, more perfect, but more friable, and altogether *cleaner* specimens, *Ichthyosaurus campylodon,* for example, is frequently found in the latter condition.

The Cephalopoda have almost always lost their shells, a trace even of the nacreous layer being rare, and are casts, often much injured and overgrown.

On a fragment of the phosphatic cast of a large ammonite, I have a specimen of a polyzoon, which evidently grew there after

* Mr. Brady's Analysis—Phosphate of Lime, 59·7; Carbonate of Lime, 26·0; Silica, 9·0; Iron and Alumina, 0·9; Magnesia, Manganese, Organic Matter, &c., 4·4.

the phosphate had become detached from the shell. In the univalves also the cast is generally damaged, and only in a few instances is there any trace of the shell. Among the bivalves *Ostrea*, *Exogyra*, *Plicatula*, *Spondylus*, *Lima*, *Teredo*, and sometimes *Pecten*, have the shell well preserved, while *Arca*, *Cucullœa*, *Nucula*, *Hinnites*, and *Perna* have almost invariably lost it, and are often waterworn. In the last named the cast not unfrequently shows ramifying cracks on the surface, which sometimes appear to be traces of a sponge or polyzoon.

With the Brachiopoda the shell very commonly remains. The delicate *Terebratulina* and *Argiope* are empty and beautifully preserved; so, too, is the thin shell of the large *Terebratula biplicata*, though it is often broken off in the process of washing. The interior of the cast is commonly of a lighter colour than in the ordinary nodules.

Of the state of preservation of the Crustacea, I have already spoken; but I may add that not a few appear to have been somewhat waterworn since their mineralization, the rostrum and the tubercles on the carapace having been rubbed away.

With regard to the Echinodermata, Zoantharia, and Protozoa I need only refer to what I have already stated.

That in the main we are right in considering the bed as the equivalent of the Upper Greensand of the South of England, I have no doubt. At the same time the large number of Gault forms present in it, the fact that some (and these commonly which have a downward rather than an upward range) have a much more uniformly waterworn appearance than others, the mode in which the deposit rests on an eroded surface of Gault, and occupies occasionally potholes in it, or is interrupted by shoals of Gault, and the fact that phosphatic nodules are far from rare in the upper part of the Gault itself; all seem to indicate that this deposit, thin as it is, contains the life history of a long period, and was preceded by a denudation (to what extent we cannot say) of the recently deposited Gault; the riddlings of which are mixed up with the fossils more proper to the epoch of deposition. At any rate, whatever may have been the duration of this period when measured by years, time enough must have elapsed for many of the casts to have been hardened, rolled on the shore, and coated with plicatulæ, before they were finally entombed in the chalky matrix, and the grains of which *Parkeria* built its dwelling must have been phosphate when they were incorporated into the walls of its elaborate chamberlets.

This leads us to consider the mode of formation of the phosphatic nodules.

Now, we have phosphate of lime in the form of the mineral *Apatite* present in granite, talc, mica, and chlorite schists, gneiss, slate, and several kinds of lava, especially the more basic. It is also present in the waters of numerous mineral springs—*e.g.*, Carlsbad, Wildegg; it has been detected in the waters of several rivers, and is probably present in all, as well as in the sea, though of course in small quantities. Again, phosphates (chiefly of lime) are present in marine and other plants.* In short, the various investigations that have been made shew that it is almost universally present in organic and not unfrequent in inorganic bodies.

Next, phosphate of lime is soluble in carbonated water, as has been ascertained by the following experiments (Bischoff "Chemical Geology," vol. ii., p. 27):—

	Water saturated with Carbonic Acid.
Apatite dissolves in	393,000 parts.
„ after brisk agitation of liquid ...	96,570 „
Artificial neutral phosphate, freshly precipitated	1,503 „
„ basic	1,102 „
Burnt bones after several years' exposure	2,823 „
Fresh ox bones in shavings	4,610 „

From which (and other examples which I have not quoted) it is obvious that the phosphate of lime present in an organism is much more soluble than in a mineral.

Again, phosphate of lime dissolved in carbonated water is precipitated by ammonia, which is a result of decomposition of organic bodies.

It appears, then, to me that the best explanation of these phosphatic nodules is to consider them formed by what, for want of a better name, we may call concretionary action. The excreta, softer tissues, and smaller bones of the Vertebrata, the bodies of numerous Invertebrata, many of which have left no other trace behind, the various marine plants which probably would flourish abundantly in a shallow sea, to say nothing of any apatite which might be present

* Fungi, 1·09 p.c. ... ...
Plants (*e.g.* nearly 17·2 p.c. in ash of Indian corn)
Corals, 0·5 to 2·0 p.c. ... ...
Shells, *e.g.* 1·0 p.c. in oyster shells ... ...
Excreta (guano), 23...60 p.c. ... ...
Bones, about 50 p.c. ... ...
} Bischoff, quoted by Holmes. "Phosphate Rocks of South Carolina," p. 50.

in the detritus wherein they were entombed, would furnish a considerable supply of phosphates; in fact, *cæteris paribus*, a shallow sea appears to me more likely to be rich in phosphates than a deep one.

The phosphates of the more perishable parts of organisms would be dissolved in the water permeating the mud, which would also be supplied with carbonic acid from decomposition, and so the mud be saturated with a weak solution of phosphate of lime. Now, if at certain points in the mud there were an excess of phosphate of lime, and especially if ammonia were being evolved at that point, the phosphate in the neighbouring solution would be precipitated; and probably (for it seems to have often happened with other minerals) all the phosphate of the surrounding mass would be precipitated about this nucleus. I regard, then, these nodules as the result of a process which took place during a part of the Gault period, and was continued during the Upper Greensand epoch; and I explain their abundance, as I have already said, by considering the seam as the riddlings of a considerable deposit. It is noteworthy how often a bed of phosphate nodules comes just above a more or less marked stratigraphical break.

In many instances these so-called coprolites might perhaps be better described as nodules of clay, saturated with phosphate of lime; but in our Cambridge deposit we must regard them as more distinctly "concretionary," seeing that only about 10 per cent. of the rock consists of silica and alumina.

Mr. Seeley's account of their formation is as follows:—"Now as many of the concretions are rolled there must have been gelatinous phosphate of lime on the shore. Sea-weeds contain in their ashes about 2 per cent. of phosphoric acid; those growing on a shore where no sediment was brought, must, during a whole geological period, have accumulated and set free by decomposition a prodigious quantity of phosphoric acid. An additional quantity would have been furnished from decaying animals, which, combining with lime would be in a gelatinous state and insoluble in water; this has been rolled into nodules with carbonate of lime and materials on the strand. . . . But it is not impossible that denudation of deposits, as of Estramadura, may have assisted in furnishing the material for the nodules of phosphate of lime, which abound in all our Cretaceous rocks."

I venture to think that my own explanation, where it differs

from this, is the more probable. Among other objections to Mr. Seeley's theory, it occurs to me, that seeing these nodules are not rare in parts of the Gault, and deposition went on during, at any rate a portion of the Upper Greensand period, we might fairly expect to find more traces than we do of the carbon contained in the marine plants, if they had been the principal agents in furnishing the phosphoric acid. Is there also any evidence for the existence of such masses of insoluble gelatinous phosphate of lime at the present day on the shores of our seas?

Next, with regard to the Physical Geography of our district. During the latter part of the Neocomian Epoch, Cambridgeshire appears to have been occupied by a shallow sea, perhaps broken here and there by small islands or shoals which were not quite out of the reach of marine denudation.

This sea was probably bounded towards the south by the Palæozoic rocks, which, though now buried a thousand feet below the surface, have been detected beneath the Cretaceous strata at Kentish Town and Harwich. The sea must have deepened towards the north, where we now find the varied beds, chiefly arenaceous, of the Lincolnshire Wolds, and the contemporaneous clays of Speeton Cliff; these mark either the persistent denudation of some neighbouring argillaceous rocks, or the not very distant embouchure of an important river, which was either denuding feldspathic rocks or had previously deposited its coarser siliceous particles. The gradual disappearance of the lower Neocomian deposits as we proceed southward from Yorkshire would seem to indicate a subsidence and consequent increase of the sea basin during Neocomian times, or at any rate a sinking of the land towards the south, even if that in the north remained approximately stable. I believe that at this time the British Isles formed part of a long peninsula, which extended in an unbroken line within our present 100 fathoms boundary (and probably further to the west also), from the north of Scandinavia to Brittany, and, very probably, curved round for a considerable distance into central France. Between the eastern face of this mountain land of Palæozoic rock and the shore of the Neocomian Ocean, which probably stretched away to the south-east, must have lain a rather level plain of Lower Mesozoic rocks, as the plains of Belgium now intervene between the Ardennes and the sea, or, more exactly still, as the lowlands of Piedmont, Lombardy, and Venetia do between the Alps and the Adriatic. Rivers

must have flowed from the eastern slopes of these Palæozoic hills across the plains of sandstone, clay, and limestone into the Neocomian Ocean. I do not think that any important stream would enter the northern part of this sea, though there must even then have been representatives of the Tyne, Humber, and Thames; for most of the drainage of this Palæozoic land must have made its way either directly to the western ocean, as is now the case in Norway, or down the valley at present occupied by the Irish Channel; though it has sometimes struck me as possible that the drainage of the upper basin of that channel may in pre-Cretaceous times have passed through the gap between Wales and Cumberland, and flowed in a S.E. direction. But I should think it very probable that the drainage of Eastern Wales, which now passes down the Bristol Channel, would formerly be emptied into this Neocomian ocean.

The Gault period must have been one of subsidence, and the Palæozoic Essex barrier was gradually covered up. Still, as one might expect, it appears to have separated two basins of deposition, for while the Gault is 100 to 120 feet thick in the Isle of Wight, 130 feet thick at Folkestone, about 150 feet at Merstham, in Surrey, more than 148 feet at Crossness (Erith), and about 130 feet thick in the Kentish Town boring, it is rather less than 40 feet at Harwich; while at Hitchin, it is* 214 feet and 284 feet at Arlesey (? 204 Whitaker. Mem. Geol. Survey, vol. iv., p. 422), and at Cambridge we have it again about 150 feet. To the north of us it appears to thin out rather rapidly, but I am without accurate information. This, however, is certain, that after a few miles south of Hunstanton it is not seen again as blue clay, but at that place and at Speeton, in Yorkshire, we find a few feet only of a red rock intervening between the Upper Neocomian and the Lower Chalk to represent the whole thickness of the Gault or the Upper Greensand, or both.

Returning, then, to the south to follow the Upper Greensand, we have it in the Isle of Wight 150 feet, Folkestone 30 feet, Merstham 25 feet, Totternhoe 7 to 10 feet, Kentish Town 13 or 14 feet, Crossness 12 feet, Harwich 22 feet, probably thin but not separated from Chalk Marl at Hitchin and Arlesey, Ashwell 1 foot, Cambridge 1 foot, Ely (?) 1 foot.†

* This seems to suggest, together with the general continuity of the Neocomian, that the basin was lower here than towards the east.

† Seeley, Geol. Mag., vol. iii., p. 304.

It is therefore evident that, by the commencement of the Upper Greensand period, some physical changes—hinted at, perhaps, by the unconformability at the base of our deposit—had cut off the principal supplies of sedimentary materials from the East Anglian and Lincolnshire area, and that it had become a shallow sea, tenanted by foraminifera, perhaps also affected by shifting currents, which from time to time swept away such lighter materials as might occasionally drift thither, and for a considerable time almost prevented any increase of sediment. Some of the smaller erratics which are found in our deposit may have been drifted down entangled in the roots of trees or attached to seaweeds, but one or two are so heavy that I think ice alone could have been the transporting agent; not, however, in true bergs, but as shore ice drifted by a coast current from Scandinavia. Mr. Seeley appears to think that the Greensand erratics came from the south—from Brittany or that neighbourhood—arguing from their absence in the Hunstanton and Yorkshire rock and its more calcareous nature. Ice-borne materials would, however, be far more likely to come from the north than from the south; and a cold current from the north, by reason of the earth's rotation, would necessarily sweep along the eastern coast of a great peninsula, shaped as this must have been.

Notwithstanding this, at present, rather slight negative evidence, I should be disposed to look towards the north-east, and suppose that Hunstanton, where only small pebbles are found, and Yorkshire lay in some tranquil bay, uninfluenced by the greater current. This, however, is only conjecture, for none of the erratic rocks are sufficiently characteristic to allow us to identify their localities with certainty. The obsidian pebbles are indeed marked enough, but I know of no accessible district where that rock is now *in situ*. The Eifel volcanos are supposed to be all post-Cretaceous, and I know of no locality for obsidian there. Still, as the Scottish volcanos had been active in more than one previous age, it may have been furnished by some now destroyed cone.*

Whether, then, we agree with Mr. Wiltshire that the North England red rock represents the Gault, or with Mr. Seeley that it represents the Upper Greensand, or as a *tertium quid* that (as I hold with respect to the Cambridge bed) it is contemporaneous with all the

* Since the above paragraph was written Mr. Seeley has stated, Quart. Journ. Geol. Soc. vol. xxix., p. 14, that he has found fragments of Magnesian Limestone. Surely this is well nigh conclusive as to a northern origin ?

latter and a little of the former deposit, it is evident that while that great mass of sediment which occupies so much of south-eastern England was being deposited, but little was added to the thickness of the beds in the north. It must, however, be remembered that probably our Cambridge bed is rather homotaxial than absolutely contemporaneous with some at least of the more western developments of the South of England Upper Greensands.

It remains only to apologise, not only for the length of this communication, but also for the absence of novelty by which it is characterised, and its too superficial character. In excuse of the latter faults I must plead that various circumstances have of late years rather diverted my attention from our local geology to other points, which have for me a greater interest; and that the paper itself has been written under the pressure of constant engagements, and often by snatches among frequent and inevitable interruptions.

Postcript.—Materials have accumulated very rapidly since the reading of the Paper; and some of the details stated above will, therefore, require modification.

Besides the papers of Messrs. Sollas, Fisher, and Jukes-Browne, which have already been referred to in the notes above, and which are worthy of careful study as throwing much light on the origin of the so-called coprolites and on the physical conditions of the Cambridge area in the Upper Greensand period, a new crustacean (*Orithopsis Bonneyi*) has been figured and described by Mr. J. Carter, of Cambridge, from his rich collection of Crustacea (Geol. Mag., vol. ix., p. 529). I should also have mentioned that several new forms of Gasteropoda, Lamellibranchiata, and Echinodermata have been described by Mr. H. G. Seeley in the Annals and Magazine of Natural History for 1861. Besides these new forms, he mentions 19 species of the class Gasteropoda and 14 of Lamellibranchiata as occurring at Cambridge, and being new to the Upper Greensand of England. These lists strongly indicate the exceptional character of the fossils of the Cambridge bed and their affinity with those of the Gault.

ORDINARY MEETING, March 1st, 1873.

Professor Morris, F.G.S., Vice-President, in the Chair.

The following Donations were announced:—

"Archives of Science and Transactions of the Orleans County Society," Nos. 1, 2, and 3, from the Smithsonian Institution of America.

"Volcanos," by G. Poulett Scrope, F.R.S., F.G.S. (new edition), from the Author.

"Quarterly Journal of the Geological Society," from that Society.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

"Journal of the Quekett Microscopical Club," No. 17, from that Club.

"South Africa and its Diamonds," by Professor T. Rupert Jones, F.G.S., from the Author.

The following were elected Members of the Association:—

Phineas S. Abraham, Esq., B.A., B. Sc., &c.; Thomas Randolph Mellor, Esq., C.E.; and William Paton Sutherland, Esq.

The following Papers were read:—

1. On the Geology of Hampstead, Middlesex.

By Caleb Evans, Esq., F.G.S.

The highest part of the ridge on the slope of which Hampstead is situated, is 443 feet above the mean level of the sea at Liverpool (the Ordnance datum), and, as is well known, the hill is capped with sand, which is exposed in several pits on the upper part of Hampstead Heath.

This sand is about 80 feet thick, and is an outlying portion of the Lower Bagshot Sands of Surrey. It extends to the north-east as far as a depression in the road beyond Caen Wood, and it is perhaps united to the similar but smaller outlier which caps Highgate Hill. The present outline of the sand on the west and south-west sides of the hill is very irregular as several ridges radiate in various directions from the central plateau.

The sand is frequently coarse, and of a yellow colour, but occasionally fine and light coloured, and in places thin seams of light coloured, fine, sandy clay or loam are interstratified with the sand. Angular masses of a ferruginous grit are seen at a few spots near the surface, and there appears to be a considerable amount of iron in the sand, as several of the springs that issue from the lower portion of the deposit are strongly chalybeate. No fossils have been recorded from the sand of Hampstead Heath.

The lower part of Hampstead Hill is occupied by the London Clay, which is about 400 feet in thickness. This fact has been ascertained by means of a well, sunk some years since on the Lower Heath,* in which 284 feet of the clay were traversed. At the base of the clay was a bed of rock, about 5 feet thick, containing pebbles and several species of shells, and below this rock were beds of mottled clays and sands 89 feet thick, representing the Woolwich and Reading Series and the Thanet Sands. This well penetrated into the Chalk to the depth of 72 feet, the total depth of the well being 450 feet.

At Kentish Town, about a mile to the east of Hampstead, the artesian well, sunk by the New River Company to the depth of 1,302 feet,† passed through the following beds:—

	Ft.	In.
Yellow and Blue Clay, with Septaria .	236	0
Sands and Mottled Clays . . .	61	6
Thanet Sands	25	0
Green Coated Flints	2	0
Chalk with Flints	244	6
Chalk without Flints	294	0
Chalk Marl	47	6
Upper Greensand, represented by bluish grey marl and green sand . .	72	6
Gault, consisting of bluish micaceous clay with two seams of green sand .	130	6
A Series of Clays, Sands, and Conglomerates, mostly of a red colour .	188	6

The true age of the last mentioned beds is doubtful. The search for water at this depth was unsuccessful, and the works were, therefore, suspended.

* Prestwich, Quart. Journ. Geol. Soc., vol. x.
† Prestwich, Quart. Journ. Geol. Soc., vol. xii.

Our knowledge of the London Clay is derived chiefly from the various excavations that have been, from time to time, made in the vicinity of the metropolis, and I now proceed to notice the principal ones that I have observed in and near Hampstead during the last ten years.

In the early part of June, 1871, some excavations were commenced in the Finchley Road, near Child's Hill, for the purpose of connecting the houses at Burgess Hill with the main line of sewer. The excavations were sunk at the southern end of the works to a depth of 31 feet, and at the north end of the drain to about 16 feet below the surface of the road. The abundance and the excellent state of preservation of the fossil shells, which were present in the lower beds exposed, made this section very interesting. During the few weeks that the works were in progress I collected nearly sixty species.*

The deposit nearest to the surface of the hill, extending to the depth of about 12 feet, consisted of a clayey sand of a yellowish or ochreous tint. This superficial deposit contained few fossils but casts of shells of the same species as those common in the bed below were occasionally found. It passed downwards gradually into a dark grey argillaceous sand, and the latter into a sandy clay, which, in the deepest part of the excavations passed to a stiff dark-coloured clay, presenting the ordinary characters of the London Clay. Nodules of septaria and of iron pyrites were not very numerous in the sandy clay; but it was in this bed that the fossil shells were in great abundance. Of these a few species were present in great numbers, and were highly characteristic, belonging to forms rare in the lower part of the London Clay.

By far the most abundant shells were an univalve, *Voluta nodosa;* and a small bivalve, *Pectunculus decussatus.* Among the other common forms may be mentioned *Natica labellata, Fusus complanatus, F. trilineatus, Rostellaria lucida,* several species of *Pleurotoma, Cardium nitens, Cultellus affinis, Pecten corneus, Modiola elegans, M. subcarinata, Cytherea tenuistria, Avicula media,* &c.

An undescribed species of *Fusus* of the slender elongated form, of which there are several examples in the Middle Eocene of Hampshire, and of which *Fusus colus* is the recent type, was occasionally found; also a *Cassidaria,* resembling *Cassidaria*

* Proc. Geol. Assoc., vol. ii., p. 283.

carinata of the Middle Eocene of Hampshire. A small and very delicate echinoderm was not uncommon. The whole fauna of this sandy clay indicates a deposit formed not very far from land under a depth of water of about 50 fathoms.

The relation of this fossil-bearing bed to the other deposits occupying this part of the London Tertiary area has been shown by means of the various excavations that have, from time to time, been made in the neighbourhood of Hampstead for drainage and railway purposes. The upper limit of the more argillaceous portion of the bed is denoted by the copious springs which appear at the surface around the hill at nearly the same level. Of these springs the best known are the chalybeate spring in Well Walk, still occasionally used for medicinal purposes, and the spring in the Conduit Fields, between Hampstead and Belsize Park, which, previously to the falling in of the North London Railway Tunnel, supplied an excellent drinking water to the neighbourhood. At about the same level there is a well at North End. A spring on the West Heath, below the flagstaff, flows over marshy ground to the "Leg of Mutton Pond." Another spring, on the west side of the hill near Church Row, gives rise to the Bayswater rivulet, which flows by Kilburn to the Serpentine; and similar springs at the Vale of Health form one of the sources of the Hampstead Ponds and of the Fleet River. The series of ponds to the west of Highgate are fed by springs rising in Caen Wood. There are also other springs and small ponds at this level in the neighbourhood.

In the year 1866 a sewer was constructed for the purpose of connecting the northern and western sides of Hampstead with the Middle Level System of the Metropolitan Main Drainage System. This sewer, commencing at North End, was formed across the north-west side of Hampstead Heath, and along Platt's Lane and the Finchley Road to West End and thence to Kilburn.

On the high ground, at the hill overlooking Child's Hill the excavations passed through the yellow Bagshot Sand, but in descending the hill towards the Finchley Road this sand became slightly more argillaceous, and contained a great amount of water. The upper part of this water-bearing sand was yellowish brown in colour, the lower portion being dark grey. Lower down the hill the dark grey sand passed into a sandy clay, which was drier and contained fossils in great numbers, especially *Voluta nodosa* and *Pectunculus decussatus*. This sandy clay extended along Platt's

Lane and the Finchley Road nearly to New West End, and it was a portion of this bed that was exposed at Burgess Hill. Across the Heath, between Child's Hill and North End, the sewers traversed the grey water-bearing stratum, and it was only at one spot that the fossiliferous bed was reached. This was in the swampy ground by the "Leg of Mutton Pond."

A similar succession of strata was seen, in 1862, in drainage works in Frognal Lane. The upper part of this exposure showed the yellow Bagshot Sand at Frognal House. Lower down the lane, near the entrance gate to Oakhill Park, the dark grey sand was seen, and at the corner of the lane leading to the parish church and near the Priory the sandy clay with *Pectunculus decussatus*, *Cardium nitens*, *Modiola elegans*, &c., was exposed.

Mr. Whitaker, in his memoir* on the geology of this district, states that he "saw some bluish green clayey sand lying at once on the London Clay in Well Walk, on the south of the Vale of Health." The deposit to which this gentleman alludes was exposed in some drains, and these drains were subsequently extended across the Heath to the Vale of Health. Here, as elsewhere, the dark clayey sand was seen below the Bagshot Sand. I did not observe any fossils in this excavation.

There have been, within the last few years, other exposures of this sandy clay in and near Hampstead, which, with the sections already noticed, furnish evidence of the thickness of the fossil-bearing stratum. At the permanent bricked shaft of the Midland Railway Tunnel, which is nearly opposite the "Belsize Arms," a few feet of this bed were traversed, but the other shafts being on slightly lower ground, passed only through the stiff London Clay. There is at that shaft, therefore, the lowest portion of the bed under consideration. From this spot the ground rises slightly to the level of the Conduit Spring, above which the Bagshot Sand sets in. A comparison of these two levels gives a thickness of about 50 feet to the sandy clay with *Voluta* and *Pectunculus*, and it appears to be about the same thickness near Burgess Hill.

The foregoing details show that this sandy clay is present at a definite level on the south, the west, and the north-west sides of Hampstead,† and there can be no doubt that it forms a continuous band underlying the Bagshot Sand as far as and also to the east of

* Mem. Geol. Surv., No. 7, p. 62. † See Map.

Highgate, since a precisely similar deposit was exposed at the time of the construction of the Archway Road, when large collections of fossils were made by Mr. Wetherell and others. The same bed was also seen in 1864 at Highgate Wood, during the formation of the Edgware and Highgate Railway Tunnels.

This fossiliferous stratum well illustrates the denudation to which the Thames Valley has been subjected. In the lower lying districts of the metropolis this bed is absent, and the characteristic shells of this zone are rarely, if ever, present in any excavations exposing the lower part of the London Clay, but on the high ground around the Crystal Palace a similar sandy clay has been seen, both at the Palace Railway Station* and in the tunnels under Dulwich Wood on the high level line of Railway. At the last mentioned locality I obtained *Pectunculus decussatus*, *Cardium nitens*, and other fossils similar to those of Burgess Hill and Highgate in great abundance.

Mr. Prestwich records a similar group of fossils from Margaretting Street near Chelmsford, Wandsworth Common, and Newnham and Clewett's Green, near Basingstoke; and this stratum probably formerly extended over the whole of the London Tertiary district, although it is now nearly restricted to those limited areas where the Bagshot Sands cap the London Clay, as around Bagshot Heath, and at Kingston Hill, Harrow, Hampstead, Highgate and Epping. The Norwood hills, where this stratum remains, are not high enough to retain the Bagshot Beds.

The nature of the deposit occupying the lower parts of the district around Hampstead has been shown by the excavations for the tunnels and cuttings of the North London and the Midland Railways.

The tunnel on the latter line, between Haverstock Hill and the Finchley Road, was excavated in very stiff and compact dark grey clay, with many zones of septaria and much iron pyrites. This clay contained a group of fossils very distinct from those of the sandy clay above. In place of *Voluta nodosa*, *Pectunculus*, *Cytherea*, &c., the most abundant species belong to such genera as *Nautilus*, *Leda*, *Nucula*, *Corbula*, *Pholadomya*, *Cyprina*, &c. *Fusus*, *Pleurotoma*, and other gasteropods are present, but the species are mostly distinct from those of the Burgess Hill and Highgate clay.

* Prestwich. "Ground beneath us," p. 36.

The characteristic species of the lower bed indicate, apparently, a greater depth of water than that under which the Burgess Hill and Highgate clay was deposited, and a similar group of deep sea shells has been obtained, on the north side of London, from the tunnel on the Great Northern Railway, near the Islington Cattle Market (formerly known as Copenhagen Fields), and from that near Primrose Hill, and on the south side from the tunnel under Sydenham Hill.

In the deposits forming Hampstead Hill we have indications of the extensive changes of condition and physical geography that took place while the deposition of a portion only of the strata of the Lower Eocene period was in progress. The Woolwich Beds, containing estuarine and freshwater fossils with occasional remains of terrestrial animals and plants, must have been deposited in areas subordinate to an extensive tract of dry land; but the highest strata of that series (the "Oldhaven Beds" of Whitaker) show an approach to marine conditions, the result of either the depression or of the denudation of the land. A period of depression is then indicated by the band of pebbles forming the "Basement Bed" of the London Clay, at which time the old land of the Woolwich period had disappeared, and the fine muddy sediment derived from more distant lands was spread over the bed of a deep and open sea. These conditions continued for a period long enough to admit of the deposition of more than 300 feet of London Clay; but towards the close of that epoch the condition of the sea bed was changed to one of shallower water, and the sediment became coarser and more sandy, the result probably of the proximity of land. Still coarser sediment marks the period of the Bagshot Sands, but owing to the general absence of fossils in these sands we are unable to ascertain the precise conditions under which they were deposited.

The coarseness of the material indicates the strength of the currents under which the sands were deposited, and that the land from which they were derived was not far distant, and this is confirmed by the fact that the only organic remains found in the Lower Bagshot Beds in England are leaves, which have been observed near Chertsey, in Alum Bay, and at a few other places.

The London Clay appears to thin out in its range to the southward, and is perhaps represented by the upper portion only of the Bognor Beds of Sussex and Hampshire, and by a bed of clay capping the cliffs on the north coast of France near Dieppe. It is

wanting in the neighbourhood of Paris; but in Belgium and Northern France it is of considerable thickness. These facts indicate that the land, during the period of the deposition of the London Clay, was situated to the southward, and the open sea to the north or north-east.

Although the shells of this deposit belong, in many instances, to genera now found in the seas of warm latitudes, the small size of the extinct species, when compared with their recent congeners, renders it doubtful if any conclusions as to the climate of the period can be formed from the presence of these forms. *Cassidaria* is a genus living at the present time in the Mediterranean Sea, and *Rostellaria*, *Pleurotoma*, and *Cancellaria* prevail in the seas of warm regions, but nearly all the species of these genera, found in the London Clay, are of small size. Until lately *Pholadomya*, a very characteristic genus of the lower beds of the London Clay at Hampstead and Sydenham, was only known as surviving in the seas of the West Indies; but I understand that Mr. Gwyn Jeffreys has recently obtained a living species of this shell from deep sea dredgings off the Coast of Portugal. The abundance of *Nautilus* and the local presence near Sheppey of crocodiles, turtles, &c., show that during a part at least of the period represented by the London Clay, this district must have possessed a higher temperature than that which now prevails in these latitudes.

The range of the Lower Bagshot Sand is very different from that of the London Clay. The sands are seen in the cliffs of Whitecliff Bay, with mineral characters very like those of the sand at Hampstead, while to the eastward, in Belgium, the equivalent beds become fossiliferous, and they are represented in the Paris basin by beds known by the name of the "Lits Coquilliers." These facts clearly indicate an extension of the sea to the southward, and probably a land surface to the north and west. We may therefore conclude that vast changes of physical geography must have taken place during the interval between the time of the deposition of the London Clay with *Pholadomya* and the formation of the Lower Bagshot Sand.

In one of Mr. Prestwich's valuable papers on the Eocene beds, that gentleman has divided the London Clay into four zones, characterised by distinct *groups* of fossils. Of these zones the first or highest consists of the clay of Southend and the Isle of Sheppey, the second zone of the Highgate Clay, the third zone includes the

clay of Primrose Hill, Copenhagen Fields, and other places near London ; and the fourth and lowest zone comprises beds containing a fauna similar to that of the Bognor Beds of Sussex and Hampshire.

The sections around Hampstead show that the *second* or Highgate zone passes gradually into the Lower Bagshot Sand, and that the Sheppey zone is not there represented. The intermingling of organic remains of terrestrial origin with marine forms, which is a characteristic feature of the Sheppey beds, in itself shows that the influences under which that zone was deposited were very local.

The fossils of the fourth or lowest zone are by no means common in the London Clay itself near London, but some of the species are met with in the Basement-bed.

There are, however, in the neighbourhood of the metropolis, at least two well defined zones, the *second* and the *third*, which, being based on changes in the condition of the sea bed, may be taken as natural subdivisions of the London Clay.

The Lower Bagshot Sand is the most recent of the Eocene beds seen in the immediate neighbourhood of the metropolis. It is, however, probable that higher strata of the Bagshot Group formerly existed on the Hampstead outlier. These higher strata consist chiefly of green and ferruginous sands with subordinate clayey beds, and are seen around Chertsey and Bagshot. The outliers of Harrow, Hampstead, and Epping have been separated from the main mass by the extensive denudation to which the district has been subjected, and the traces of sandy gravel and of rounded flint pebbles which are seen at a few spots at the top and on the higher slopes of Hampstead Hill, may perhaps be the remains of these higher deposits.*

Near the level of the junction of the sand and clay, the superficial deposit frequently consists of a sandy clay forming a good brick-earth, which has for several years been worked in the fields between Hampstead Heath and Highgate, and more recently in the fields between South Hill Park and Parliament Hill. The subsoil in the lower parts of Hampstead consists apparently of the London Clay, somewhat modified by atmospheric action.

* Mr. Searles Wood, jun., considers that the pebbly gravel on which the fir trees near the "Spaniards" grow, is distinct from the other superficial deposits on Hampstead Heath, and is of Postglacial age.—Quart. Journ. Geol. Soc., vol. xxiv., p. 466.

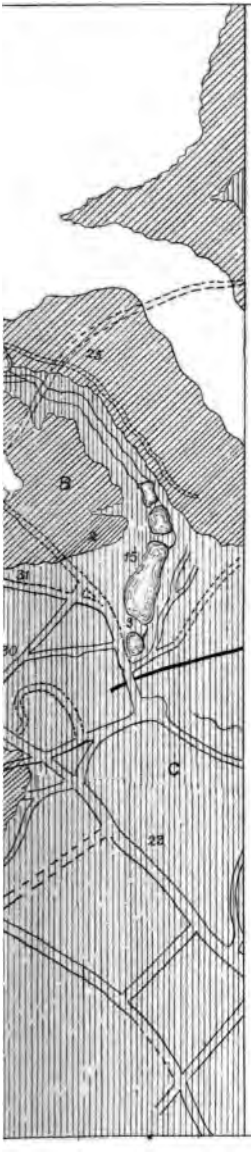
It is possible that within a short distance from the northern slope of the hill, traces of the Glacial Beds may be found. The sections of these remarkable beds lately exposed at Finchley, three miles to the north of Hampstead, have been described by Mr. Henry Walker, F.G.S.* These deposits consist of clays full of subangular masses of chalk and of other rocks, and containing fossils derived from the Oxford Clay and the Lias, and associated with the chalky clays are beds of gravel and sand.

These Glacial deposits occupy a plateau varying in height from 230 to 300 feet above the sea, and extending from the northern slope of Highgate Hill as far as Whetstone in a northerly direction, and to Church End, Finchley, to the north-west. At Fortune Hill, in the Finchley Road, one mile south of Finchley and two miles from Hampstead, there is a portion of these beds remaining.

The position in which these Glacial Beds are now found shows that the district has suffered extensive denudation at two distinct periods, the one being pre- and the other post-Glacial. The Glacial Beds, both at Finchley and Whetstone, rest on London Clay containing *Nautilus*, but there is in that locality no trace of the sandy clay with *Pectunculus* which constitutes the upper member of the last-named formation. A well section at the Hyde,† about two miles west of Finchley, shows that at that spot there is not more than 66 feet of London Clay, and if it is assumed that the deposit is nearly horizontal (as is probably the case), it appears from the difference in height between the Hyde and Finchley that the thickness of the London Clay at the latter place does not exceed 170 feet. Near the Barnet Railway Station, to the east of Whetstone,‡ the London Clay is 115 feet thick. These facts show that prior to the deposition of the Glacial clays and gravels, the Eocene beds had been extensively denuded, and since the formation of the Glacial deposits further denudation has taken place, and the streams have deepened their valleys in some instances as much as 60 feet; in fact, some of the streams take their rise in the Glacial gravels. Whether the extensive denudation to the west and south of London (which has separated the sands of Hampstead from those of Harrow and Chertsey, and the Burgess Hill sandy clay from that of the Crystal Palace) took place prior or subsequently to the Glacial Epoch remains to be proved.

* Proc. Geol. Assoc., vol. ii., p. 289. † Whitaker. Mem. Geol. Surv., sheet 7.
‡ Op. cit.

G.R.De Wild 'ht.



MAP
to illustrate the
GEOLOGY of HAMPSTEAD

A.— *Lower Bagshot Sand.*
B.— *Sandy Clay with Pecten eulve*
C.— *London Clay with Philadomya.*

1.— *Jack Straw's Castle*
2.— *Hampstead Heath*
3.— *Well, Lower Heath*
4.— *Childs Hill.*
5.— *Burgess Hill.*
6.— *Well Walk.*
7.— *Conduit spring*
8.— *Belsize Park.*
9.— *Shaft, North London Rail.*
10.— *West Heath.*
11.— *Flagstaff.*
12.— *Leg of Mutton Pond.*
13.— *Church Row.*
14.— *Vale of Health.*
15.— *Hampstead Ponds.*
16.— *North End.*
17.— *Platts Lane*
18.— *West End*
19.— *Frognal House*
20.— *Oakhill Park.*
21.— *Parish Church.*
22.— *Shaft, Midland Railway.*
23.— *Haverstock Hill*
24.— *Finchley Road.*
25.— *Brick fields.*
26.— *Kidderpore Hall.*
27.— *High Street.*
28.— *Roslyn Bank.*
29.— *Flask Walk.*
30.— *Downshire Hill.*
31.— *Willow Road.*

W. West & Co. imp.

The country around and to the north of Hampstead is much more diversified by hills and valleys than the other parts of Middlesex are, and the superior character of the scenery of North Middlesex is owing, I am inclined to think, to the circumstance that the Lower Bagshot Sand, and the Glacial Beds have there been preserved.

As has been already observed, the outline of the sand at Hampstead is very irregular on all sides except the one to the north-west.* On the West Heath the upper part of a deep and narrow valley extends nearly to the flagstaff by "Jack Straw's Castle." The ridge flanking this valley on the south side extends with an irregular outline nearly to Child's Hill; another spur extends to Kidderpore Hall, south-east of which a deep valley separates that spur from the ridge on which Oakhill Park and Frognal are situated. Another broad inlet faces the south, and the higher part of this valley extends to Church Row, and to the south of this valley the sand projects as far as the Conduit Spring and Roslyn Bank. On the eastern side of the hill a valley descends from Flask Walk to the Lower Heath. This valley unites, at its lower termination, with the valley forming the eastern boundary of Hampstead Heath, in which the well-known Hampstead Ponds are situated. The highest part of this last valley is situated between "Jack Straw's Castle" and the Vale of Health, and the ridge separating it from that on the West Heath is the narrowest part of the outlier. The ridge to the east of the lastly described valley extends to Parliament Hill (which perhaps still retains a very small portion of the Bagshot Sand), and between this ridge and Highgate there is a similar valley, in which the Highgate Ponds are situated.

The bottoms of most of these valleys are occupied by small streams, among which may be noticed the branch of the Brent rising on the West Heath, the Bayswater rising near Church Row, and the branches of the Fleet rising respectively at Flask Walk, the Vale of Health, and Caen Wood; and it appears to me not improbable that these valleys have all been excavated since the district was raised above the level of the sea by means of the streams that now flow through them.

All these streams take their rise from the springs that issue from

* See Map.

the lower portion of the Bagshot Sand. This sand, resting on the impervious London Clay, must always have been (whatever was its extent) a water-bearing stratum. On the first emergence of the district from below the level of the sea the whole of the sand must have been saturated with water, and the immediate effect of the tendency of that water to reach the lowest level would have been the formation of chines, or ravines, around the coast line down which the water would flow. Time would then only be required to enable the streams thus formed to cut back their valleys to any extent, until the water-bearing bed in which they had originated had been entirely removed. Slowly and imperceptibly this process has probably been continued from the time of the emergence of the land to the present day; and by these means not only have the diverging valleys around Hampstead and Highgate been formed, but the outlier itself may also, in course of time, have been separated from the sands of Harrow and Epping, and even from the extensive tract around Bagshot. The Norwood Hills, which present an outline somewhat similar to the contour of the district around Hampstead, have resulted from the same cause; but in that instance the denuding action has been continued to a greater extent, and nearly the whole of the water-bearing deposit has been removed.

The same kind of action appears to have operated in the country to the north of Hampstead, where the Glacial gravel, resting on the London Clay, forms a similar water-bearing stratum, in which streams take their rise, and these streams have also excavated their valleys to a lower level.

That much denudation has resulted from the action of the sea on land slowly rising above its level is highly probable, and many hills and valleys now existing, are the result of the upheaval and the fracture of the strata; but in a district like Middlesex, where the stratification is nearly horizontal, it is in the subaerial action constantly in operation that the cause must be sought of the present contour of the country.

2.—On a Recently Exposed Section at Battersea.

By John A. Coombs, Esq.

This section was exposed on a piece of ground recently acquired by the London Gas-Light Company for a Gasholder Station. It is situated to the north of the Prince of Wales' Road, Battersea, between the high-level lines of the London, Brighton, and South-Coast, and the London, Chatham, and Dover Railways, near the point of their separation after crossing the Thames near the Chelsea Suspension Bridge. The excavations were commenced at the latter end of last year, for the purpose of constructing two gasholder tanks, each 185 feet inside diameter. The total length of the excavation, therefore, was about 400 feet, by about 200 feet in width, and 30 feet in depth, the direction of the longest distance being very nearly from N.W. to S.E. (see Fig. 1.)

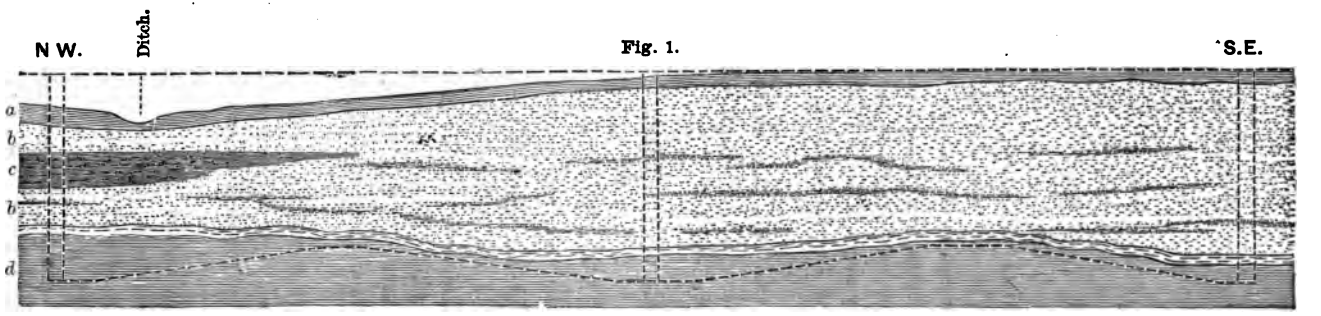
The average surface of the ground was 12ft. 9in. above the Ordnance Datum Level, or 3 inches above Trinity High Water Mark. The general Section was as follows:—

Alluvial Soil and Vegetable Mould . .	2 feet.
Thames Valley Gravel	22 ,,
Altered London Clay (brown) . . .	1 ,,
London Clay (excavated)	5 ,,

These thicknesses are merely averages, as in many places pot holes occurred in the London Clay, which would add at least 3ft. to the thickness of the gravel given above. The surface of the ground, too, was somewhat irregular, thus bringing the gravel in some instances to within a few inches of the surface. The 2ft. of soil given above includes not only vegetable mould, but rubbish, which had been shot in places.

The Thames Valley Gravel consisted of intercalated bands of sand and ballast of varying degrees of coarseness. Some of these consisted of fine sharp sand, which was well adapted for the mortar used in the construction of the tanks, others were so loamy as to be altogether unfit for that purpose. Many of the layers consisted entirely of sand, more or less coarse, but containing very few pebbles, while others were composed of larger fragments of older rocks, and mixed with but little sand. These older rocks were of several varieties, such as Woolwich pebbles, pebbles of sarsenstone,

Fig. 1.

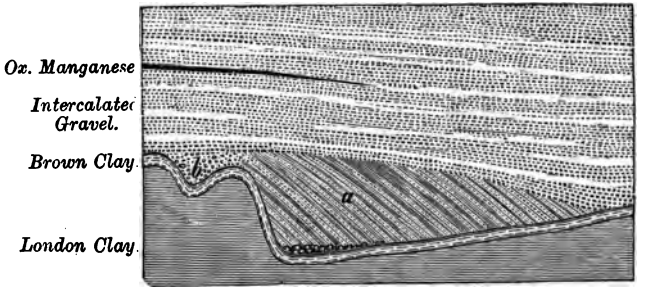


a. Alluvial. *c.* Black Clay.
b. Gravel. *d.* London Clay.

0 10 20 30 40 50 60 70 80
HORIZONTAL SCALE.

0 10 20 30 40 Feet.
VERTICAL SCALE.

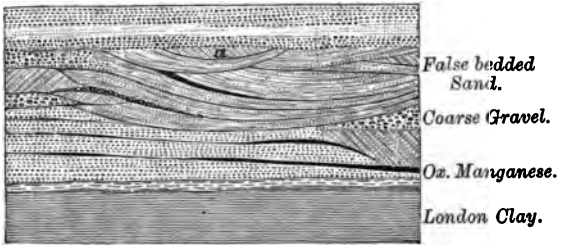
Fig. 2.



a. False bedded Sand.
b. Coarse Gravel.

0 2 4 6 8 10 Feet.
NATURAL SCALE.

Fig. 3.



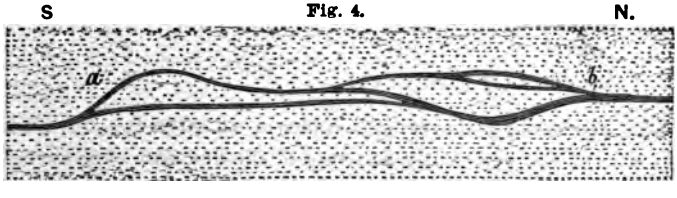
a. False bedded Sand with Chloritic Iron.

0 2 4 6 8 10 Feet.
NATURAL SCALE.

green-coated "bull-head" flints, Chalk flints—some hardly worn, and retaining even the white covering of ordinary spongeous Chalk flints, but mostly in the form of the common rolled pebbles of flint, of which the gravel is chiefly composed. There were also pebbles of sandstone (Millstone Grit?), quartzite (Lickey pebbles), and white quartz.

Some of the bands of sand in this section contained a large proportion of ferruginous matter in the form of grains of chloritic iron, disposed in veins, which showed the angle of bedding with facility, and where, but for these veins, no bedding would have been observable. The bands containing this chloritic iron were mostly false-bedded, and of limited extent. There were also a few layers of pebbles extending for some distance, which were covered with a black, and, when freshly exposed, unctuous material, which Mr. W. H. Hudleston, F.G.S., has shewn to be composed of oxide of manganese. In some cases, layers of this black gravel, after extending for some distance as one band, were suddenly divided, and continued still farther as two layers separated by a foot or more of intervening gravel. None of these layers exceeded five or six inches in thickness, and in general the thickness was not more than two or three inches.

Fig. 4.



A remarkable instance of this black gravel is represented in Fig. 4, shewing very irregular deposition; the gravel both above and below it was of the coarse description, and with no intercalated sand or other clue to the direction of the bedding at this spot. This figure, though not drawn to actual measurement, is a close approximation to the truth, the distance from *a* to *b* being about 10 feet.

Several examples of false-bedding occurred in the section, one of the most marked of which is represented in Fig. 2, where the falsely-bedded sand was deposited in one of the pot-holes in the London Clay, and was inclined at an angle of 30°. The section represented in Fig. 3 contained a great diversity of material within a small compass, there being here depicted falsely-bedded sand, oxide of

manganese bands, layers with chloritic iron, and intercalated beds of gravel of all degrees of coarseness. Both these sections (2 and 3) are taken from W. to E., and it was, generally speaking, in this direction that the falsely-bedded sand throughout the excavation was most highly inclined.

Towards the north-west portion of the excavation, and about 8 feet above the London Clay, was a deposit of blueish-black sandy, or rather muddy, clay, containing layers of sub-angular pebbles, and frequently intersected with vertical rootlets of plants. It also contained several patches of red ferruginous loamy sand, the difference between these patches and the surrounding material probably arising from a higher oxidation of the iron. This deposit thinned out from a thickness of 5 feet at the limit of the excavation to nearly the centre of one of the tanks, where it was entirely absent (see Fig. 1). The peculiar feature of this deposit was that it was covered by, as well as rested upon, a portion of the gravel. The section at the N.W. extremity of the excavation was as follows, the bottom of the cutting in this case corresponding with the bottom of that given above :—

Alluvial Soil and Made Ground . .	2 feet.
Gravel	4 „
Black Clay	5 „
Gravel	8 „
London Clay (excavated) . . .	6 „

This Black Clay had every appearance of a local freshwater, muddy deposit, but was apparently destitute of the fluviatile shells usually found in river accumulations.

An interesting series of mammalian remains were obtained from the Valley Gravel, which, considering the limited extent of the excavation, and the number of specimens destroyed in the removal of the material, shews this section to be fully as prolific in these remains as the long-worked pits of Erith or Crayford. The specimens have been examined and identified by William Davies, Esq., of the British Museum, who kindly undertook to compare them with those in the national collection. The following is a list of these remains :—

Elephas primigenius, Blum. Portion of lower jaw and tooth, and the shaft of a humerus of a young individual.

Rhinoceros tichorhinus, Cuv. Part of a cranium, a lumbar vertebra, a right metatarsus, and a left metacarpus.

Equus caballus fossilis, Linn. A right metacarpus, a right radius, and an upper molar.

Bos. sp. Cervical vertebræ.

Cervus elaphus, Linn. Portion of left ramus of lower jaw, and portion of a right radius.

Cervus tarandus, Linn. The base of a shed antler. (This had suffered considerable attrition.)

There were also found a rib and a portion of an illium of a *Cervus* (species indeterminable), besides many other fragments too small or too much mutilated for recognition. But the most unusual fossil found in such deposits was that of *Pliosaurus*, a portion of the paddle-bone of which was found associated with the remains above mentioned. This fossil, which was probably derived from the Kimmeridge Clay, shewed evident signs of attrition, but not so much as to efface the marks of muscular attachment; it was, moreover, charged with peroxide of iron. Search was made in the anticipation of shells of *Cyrena (Corbicula) fluminalis* being associated with these remains, but without success.

Immediately beneath the Thames Valley Gravel was the London Clay, possessing all the typical features of that formation, without any of the loamy gradations found in higher parts of the metropolis. The top of the clay, however, to a depth varying from 9 to 12 inches, was of a brown colour, resembling the brown (altered) London Clay found at Hampstead and elsewhere.

The clay, as will be seen by the dotted line in the diagram (Fig. 1), was excavated only to a depth of a few feet, thus preventing a great number of fossils being obtained. Those found, however, are sufficient for comparison with the zones of fossils found in larger sections, and thus may afford evidence of the amount of denudation to which the clay had been subjected at this spot before the deposition of the gravel. By far the most abundant fossil found in the London Clay was the *Pentacrinus sub-basaltiformis*, which was obtained in the rounded angular, as well as the perfectly cylindrical form. The following Mollusca were also obtained:—*Nautilus regalis*, *Pyrula Smithii*, *Fusus bifasciatus*, *Voluta Wetherellii*, *Pleurotoma teretrium*, *Natica labellata*, *Dentalium*, sp., *Leda amygdaloides*, *Nucula Bowerbankii*, *Cryptodon angulatus*, *C. Goodhallii*, and *Syndosmya splendens*. *Teredo* borings, *Serpulæ*, and teeth of *Lamna* complete the list of organic remains.

Septaria were abundant in the clay, many of which contained drift-wood, bored by the *Teredo*, one contained a *Nautilus regalis* as a nucleus, and several exhibited the usual crystallizations of calcite, heavy spar, and iron pyrites. Selenite, however, was very scarce in the clay, being found only in small crystals, and these by no means numerous.

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY, March 21st, 1872.

Director:—Professor Morris, F.G.S.

On assembling in the Great Hall of the Museum, the Members were addressed by Professor Morris, who prefaced a descriptive lecture on the Minerals contained in the great horse-shoe case by some valuable general remarks on minerals, their composition and classification, more especially noticing those which enter into the composition of rocks, and which, compared with the number of described minerals, are remarkably few, probably not more than thirty or forty altogether.

The arrangement of the minerals in this museum is exceedingly simple as well as most useful to the geological mineralogist, since it is one founded upon a classification according to *bases*. Thus, all the Carbons are together, including diamonds, coal, anthracite, bitumens, graphite, amber, &c. All the Limes, the carbonates, the sulphates, and the phosphates; then all the Silicas, including the agates, quartz, cairngorm, &c.

At the conclusion of a very instructive lecture, a vote of thanks was heartily accorded to Professor Morris.

EXCURSION TO MAIDSTONE, April 2nd, 1872.

Directors:—Professor T. Rupert Jones, F.G.S., &c., Professor Tennant, F.G.S., and W. H. Bensted, Esq.

On arriving at Maidstone, the party was met by W. Bensted, Esq., jun., and conducted to the "Charles Museum." This, the free public museum of the town, is in a fine old manor house, now being enlarged and renovated. Many of the rooms are filled with a miscellaneous collection of antiquities, pictures, and other objects

of general interest, amongst which may be perhaps specially mentioned, a very valuable collection of Saxon weapons, utensils, and ornaments, found at Sarre, near Canterbury. In the old picture-gallery is at present preserved a collection of fossils, which includes many interesting specimens; and conspicuous among these are some exceedingly beautiful Chalk fish remains, from Barham Downs, near Maidstone. These are chiefly of the genus *Beryx*, with one or two specimens of *Dercetes elongatus*. In a small upper room is a collection which gives a special value to the Maidstone museum, consisting, as it does, of the vegetable remains found in the Lower Greensand of the neighbourhood of Maidstone, collected during many years by Mr. Bensted, who has, with a fatherly care, preserved for science the organic remains occurring in the beds worked in his extensive quarries.

The following species, amongst others, are here represented:—*Endogenites erosa*, *Clathnariophylli* (leaves), *Dracœna Benstedi*, *Sigilaria*, *Stigmaria*, and a plant allied to Cactus.

A beautiful, but as yet undescribed encrinite, from the same beds, is also to be found in this portion of the museum.

After luncheon the party proceeded to the well-known Iguanodon Quarry, from which Mr. Bensted obtained the Iguanodon described by Mantell, and now in the British Museum. The quarry in which this valuable fossil was found is not now being worked, and the sections here are obscured by *débris*. There is, however, in the quarry a ridge which may easily be mistaken for a mound of rubbish deposited by the quarrymen, but which is of far more ancient origin, since it is no other than the Post Pliocene infilling of a great fissure in the Lower Greensand. The rock having been removed on either side by the operations of the quarrymen, the mass filling the fissure has been left as a dyke-like ridge. It consists of argillaceous matter, and "gravel composed of angular broken Chalk flints, flint pebbles, subangular fragments of the Hastings Sandstone, and a few pieces of ironstone from the same beds, with angular chert, and, rarely, quartz pebbles."

In the fragments of ragstone lying about the quarry were found numerous specimens of *Molluscite*. This name was given by Dr. Mantell to certain small, dark-coloured masses, believed by that author to owe their origin to the animal matter of molluscs.

At a short distance from this interesting quarry, a point is gained from which an extensive view is obtained, embracing a

considerable portion of the Valley of the Medway, and the geological structure of this part of Kent is distinctly seen. The Lower Greensand forms the eastern side of the valley. The strata are here nearly horizontal, and the depth of the valley is almost a measure of the thickness of the formation at this place, since at the lowest point only a few feet of the Lower Greensand are to be found covering the Weald Clay which lies beneath. There is thus found to be seventy or eighty feet of the Lower Greensand, which include the lower beds of that formation, equivalent to the Atherfield Clay of the Isle of Wight.

The Weald Clay has been bored by well-sinkers to a depth of seven or eight hundred feet, and the bottom of the formation not reached. It is believed to be here 1100 feet thick.

At the opposite side of the valley, the Gault overlies the Lower Greensand, and higher on the hill-side, the Chalk Marl and Lower Chalk are found, while the upper portion of the bounding ridge is the Upper Chalk. Post Pliocene river-gravels occur in the valley, and these contain remains of *Elephas*, *Rhinoceros*, *Bos*, *Equus*, &c.

Professor Rupert Jones pointed out the physical and geological features of the district, as well as the very distinct indications of the formations cropping out along the valley. The bare, down-like character of the Upper Chalk land, the small trees and arable character of the Chalk Marl zone, and the large trees and park-like appearance of the land overlying the Gault, very clearly mark out the breadth of each formation.

The ancient ridgeway, or Pilgrims'-way, running along the vale to Canterbury, is visible along the side of the hill; and the Druidical stones called "Kit's Cotty House," are seen in the distance. The great northern Chalk boundary of the Wealden area, the North Downs, is here broken through by one of those lateral valleys which form remarkable features in the physiography of Kent and Surrey. This break forms the valley of the Medway, which here takes a course almost due north. The lateral valleys of the Weald, interrupting at intervals the continuance of the bounding ranges of Chalk downs, were probably caused by the disruption of the strata at the time of the elevation of the Weald. Breakages occurred at these points possibly in consequence of the greater tension produced by elevations or bosses on the great Palæozoic ridge, which, there is reason to believe, underlies the south-east of England. The other breaks in the range of North Downs are the valleys

of the Dart, the Wey, and the Mole, which rivers run northwards into the Thames, and with the Medway drain a large portion of the Wealden area. Curiously enough, four corresponding river valleys break through the range of South Downs, and thus the remainder of the Weald is drained by four rivers running southwards into the English Channel. It is worthy of note that these great breaks in the ranges of Downs have bell-shaped entrances at their Wealden termination, and this has led some observers to conclude that the rivers ran originally in directions opposite to their present courses and emptied themselves into a great river which flowed through the present Weald of Kent and Surrey in the direction of its length.

An extensive quarry belonging to Mr. Bensted was next visited, and here the "Kentish rag" was well seen. This valuable building stone, so much used at present, as in the past, for the churches of London, is a tough, bluish limestone, occurring in layers of from a foot to three feet in thickness, and alternating with beds of a soft, sandy stone called "hassock." Some of the best of the ragstone contains 90 per cent. of carbonate of lime, while the hassock has but ten or twelve per cent. The amount of ragstone quarried in the neighbourhood of Maidstone is very great, Mr. Bensted alone sending away nearly 1,000 tons weekly. This rapid removal of the rock has been going on for centuries; most of the ancient churches and castles of Kent being constructed of this material, and so ancient a building as the White Tower of London is partly built of Kentish rag. Two blocks of the ragstone, lying at the bottom of the quarry, on being split showed faces covered, in the one case with *Trigonia alæformis*, and in the other with this species and *Gervillia anceps*.

Associated with the rag is a considerable quantity of chert and black flint, containing spiculæ of sponges. Fossil wood is often found in these beds, and some of this is bored. Leaving the ragstone quarries, a path following the course of the river was taken. At a little distance in this direction occurs a tramway running to the river bank through an old quarry, in which are seen as many as twelve of those dyke-like ridges, of which one was observed in the Iguanodon Quarry. These, the infillings of as many fissures in the Lower Greensand, are parallel to each other and to the river valley, and therefore at right angles to the great Wealden valley. The argillaceous earth of which they are largely composed is a

good brick-making material, and used sometimes for that purpose.

After passing the interesting and picturesque ruin of Allington Castle, the river was crossed at Allington Lock, and the village of Aylesford was soon reached. Near this village a very fine section is exposed. A bed of fine and pure white sand, 25 feet in thickness, forms the uppermost portion of the Lower Greensand at this place, and upon the eroded surface of this remarkable bed lie 20 feet of Post-glacial sands and gravels, containing mammalian remains, some teeth of *Elephas* being carried away by members of the party. Beds of similar gravels are met with at elevations 300 feet above the bottom of the valley. The white sand is used for glass making, and a considerable quantity of this beautiful material is taken from this place annually.

After crossing the Medway, the Members made their way to Aylesford Station, from which they returned to London.

ORDINARY MEETING, April 5th, 1872.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Défense des Colonies," by Joachim Barrande, from the Author.

"Distribution of the Cephalopods," by Joachim Barrande, from the Author.

"Cephalopods," by Joachim Barrande, from the Author.

"Pteropods," by Joachim Barrande, from the Author.

"Trilobites," by Joachim Barrande, from the Author.

"The Testimony of the Rocks," by Hugh Miller, from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Journal of the London Institution," from that Institution.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Journal of the Quekett Microscopical Club," from that Club.

"Proceedings of the South Wales Institute of Engineers," from that Institute.

"On Gossans," by William Argall, from the Author.

Alfred Bell, Esq., was elected a Member of the Association.

The following Paper was read :—

On Excavations on the Site of the New Law Courts.

By Wilfrid H. Hudleston, Esq., M.A., F.G.S., F.C.S., and F. G. Hilton Price, Esq., F.R.G.S., M.A.I.

It is well known to most of the inhabitants of London that the Government have decided to erect the long-talked-about Courts of Justice in the Strand, upon what is called the Carey Street site. This site, occupying an area of seven acres, was cleared of its houses about three years ago, when nearly 4000 people were turned out.

It is recorded in the "Memorials of Temple Bar," by Mr. T. C. Noble, that early in the 14th century the Strand outside Temple Bar was nothing better than a marsh, and that two bridges had in later times been thrown across two rivulets, which ran from the higher ground to the Thames. One of these bridges, consisting of stone, and 11 feet in length, was found covered up by rubbish to the eastward of St. Clement's Church, in 1802. This was possibly the very bridge mentioned in the reign of Edward III., as built by the Templars by the "King's command."

Since the "Rookery" on this site has been swept away, extensive excavations have been made for building the foundations of these Law Courts. We have been permitted, from time to time, to visit these excavations, through the courtesy of Mr. Lett, the foreman to the contractors, who, in conjunction with Mr. Collins, the Clerk of the Works, has rendered us every facility for seeing anything of interest that has been discovered.

The area excavated is pretty nearly square, being about 500 ft. in length on the Strand or S.S.E. face, and about the same on the Bell Yard, or E.N.E. face. To simplify matters, the Strand face will always be described as S., the other sides and angles accordingly. The floor of the excavation at the Temple Bar corner is about 33 ft. above the Ordnance datum line, but trial shafts have been sunk as low as 28 ft. above the datum line, in all cases terminating in the London Clay. It is to be regretted that a more accurate record of the various layers passed through on sinking these shafts has not been preserved. Had the measurements been geologically reliable, very interesting general sections each way might have been constructed.

Those who have been engaged on the work of excavation recognise four varieties of beds, which we may describe as—

a. Brick Rubbish and Made Soil.—This consists largely of the various materials of previous houses decaying, and being built over during a long period of time. The many interesting remains of glass, pottery, and other relics of man found in this division, belong rather to the domain of the archæologist than to that of the geologist. There has, however, been found the upper portion of a human skull, which, as it lay at the very bottom of a bed of mould projecting deeply into the gravels, may fairly be entitled to some notice in this paper. It may be as well here to draw attention to the extreme irregularity in the line of junction between the *brick rubbish* (including under that name also the mould beds and other shifted materials), and the underlying *gravels.*

Many an old foundation may be seen projecting like a promontory into the subjacent sandy gravels, and where these thin out into the London Clay itself. The numerous old wells also tend to confusion in this respect. Such accidental thickening of surface material may be the cause of the remarkable variations in the depths assigned to *made earth,* given in the various borings executed in and about London. That at the Bank of England, for instance, where 22 ft. of made earth and only 4 ft. of gravel are stated to lie between the surface and the London Clay.

b. Gravels and Sands.—The gravels are of considerable utility to the contractor, as they are used in making the concrete which is to form the foundation of the future Law Courts, and for this purpose are sifted from the sands, with which they are largely mingled. Such a very extensive sifting as these have undergone throughout the entire area, would inevitably lead to the discovery of most of the organic remains therein contained. It will be seen, however, subsequently, that very little has been found of this nature. A more detailed notice of these gravels and sands, as regards their composition and mode of occurrence, will be given when we come to consider the special sections.

c. The so-called Red Loam or Wet Clay.—In the majority of cases the above-mentioned beds terminate very abruptly, upon a moderately uneven surface of a fox-coloured clay, which itself tones down, in some places gradually, in others with an appearance of demarcation, into the regular blue London Clay. It is, in fact, the London Clay *in situ,* but partially affected by oxidation, and infiltra-

tion from above. The nature of these changes, which extend also to the included septaria, are of considerable interest. On comparing, for instance, dried and partially powdered specimens of the red and blue clays, we find in both a most remarkable freedom from grit; the particles are of excessive fineness, and those which are larger than others seem to be merely cakes of the very finest powder agglutinated by pressure. In the case of the red clay, these particles appear to have a reddish smear, the colour of which is principally due to ferric oxide.

c' The fourth variety of material observed in these excavations is the regular Blue London Clay, with its large septaria, *Teredo*-bored wood, pyrites, *Nautilus*, *Fusus*, &c., forming the basis of the whole. A more detailed mention of the fossils found will be attempted subsequently.

In the blue clay, extremely minute fragments of iron pyrites are distinctly noticeable with a lens in considerable abundance, and tend, in addition to the grey colour of the general substance, to give that dark hue to the unaltered portions of London Clay. The indications of ferrous oxide in the *blue clay* are very strong, whilst in the *red clay* ferric oxide would appear to predominate. The actual amount of metallic iron in air-dried specimens of the two clays is about $4\frac{1}{4}$ per cent. in the blue clay, and 5 per cent. in the red clay. No iron pyrites could be made out in the red clay, and as no sulphuric acid is traceable after fusion, it may be pretty confidently stated that none exists in the specimens examined. Carbonates of lime and magnesia, in almost dolomitic proportions, exist to some extent in the blue clay, much less so in the red. The amount of phosphoric acid in the blue clay is considerable, in the red it has not been determined. The principal changes which the London Clay, in contact with the porous gravels, undergoes, may thus be summed up. Conversion of ferrous oxide, which exists partly, perhaps, as carbonate, but principally as one of the basic elements of the silicate comprising the bulk of the mass, into ferric oxide, oxidation of the pyrites, and removal, to a considerable extent, of the resulting sulphuric acid, and diminution of the carbonates of lime and magnesia.

The septaria in the red clay are equally attacked. Instead of the pale-grey compact cement-stone, we have, indeed, the lenticular form it usually assumes, but the substance is a yellow, greasy

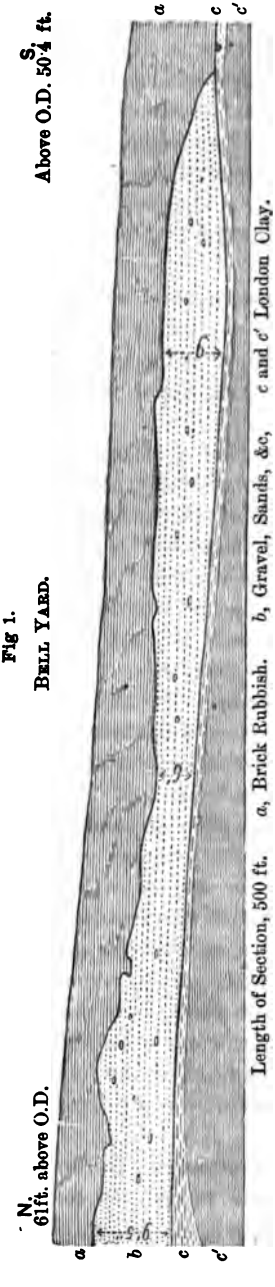


Fig 1.
Bell Yard.

mass, more or less crumbly, according to the change undergone. A specimen compared with one taken from the blue clay immediately below gives 46 per cent. of matter insoluble in acid, as against 23 per cent. in the specimen from the blue clay, showing a loss of upwards of 20 per cent. of its carbonates. Again, the iron, which is pretty plentiful in the ordinary cement-stone of the London Clay (the concretion being analogous to the well-known clay ironstones of other districts), exists almost entirely in the dyad state, except at the edges; whereas, in the decomposing form occurring in the red clay it has passed into the triad state, and some of it into that form of ferric oxide which is insoluble in hydrochloric acid.

General Sections.

Having thus briefly noticed the four varieties of beds here occurring, the two last being simply different conditions of the London Clay, we may now advert to their respective thickness and position with regard to each other.

Fig. 1 may be taken to represent a section about 500 feet long, from N. to S., parallel to and in the vicinity of Bell Yard, that is to say, down hill, and at right angles to the course of the river. Here the original surface slopes from 61 feet above Ordnance datum line to 50·4 feet above it. The accumulation of rubbish at the back of Temple Bar unduly thickens the amount of *made earth* hereabouts. This circumstance, viz., the great thickness of surface accumulation, to a certain extent interferes with comparisons afterwards taken

at other points of the Thames Valley. It especially affects the S.E. corner of our area. Along this section generally the thickness of surface material is from 6 to 7 feet.

It will be observed that the *gravels and sands*, according to these measurements (which are partly derived from the test-hole borings) have a thickness of 9·5 feet in the N.E. corner, and after maintaining a general thickness of about 7·5 feet, except for a very short distance, thicken out again to 9 feet further down the hill (a thickness of 11 feet is attained a little to the west of the line of section) and then, after thinning away to 2 feet as we approach the Strand, disappear rapidly close to Temple Bar, where the *Brick Rubbish* rests directly on the *London Clay*. This would also appear to be the case all along the lower or Strand face of the excavation, a little gravel in occasional hollows of the clay alone being noticeable.

The curve of London Clay surface here exhibited is, as regards the S. part, obtained from actual observation, to be shown in a special section presently. The northern portion of it is assumed from test-hole measurements. The most remarkable circumstance with regard to it is the fact of the northward slope of the portion nearest the Strand. If this is continued much to the right of our section there must be a sort of outcrop of the London Clay along the line of the Strand, which is not indicated even in the last edition of Mylne's most excellent map. This may perhaps account for what we know of the condition of the Strand in the 16th century, where the road is described as being "full of pits and sloughs, very perilous and noisome" to the passers-by. That the clay forms the original surface here without any covering of gravel, may be inferred from the traces of tree roots which are still obvious at considerable depths. The name Holywell Street likewise is suggestive of springs in these parts, which rather points to a similar conclusion.

Bearing these facts in mind, and coupling the northward slope of the clay with the rapid disappearance of the gravels of the Law Courts area, it would seem that there is a regular bench of London Clay, having a moderate northward slope, interposed between the gravels of this area, and those of the declivity immediately above the Thames. The height at which these gravels disappear may be stated to be about 35 feet above Ordnance

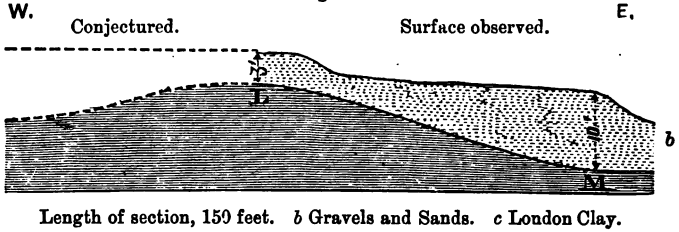
datum line, as far as we can judge. If we add six feet as the mean of surface accumulation, this would bring the northern or upper margin of the clay bench to 41 feet above Ordnance datum, reckoning from the surface.* It is worth observing, also, that in the northern portion of this section there is a point where the surface of the London Clay falls away again to the north, and, although a mean rise of 8·3 feet is established in the 500 feet, there are two instances where the slope is the reverse way for a considerable distance. This peculiarity will be again alluded to in describing the special sections.

Referring again to Fig. 1, the dotted line following the curve of the London Clay indicates the extent of the *red* or *altered clay* on the S. as observed, on the N. as conjectured. The vertical scale is, of course, very much exaggerated.

A section from E. to W. parallel to the Strand would show a great roll or swelling which the London Clay makes through the middle of the area, attenuating the gravel on either side, and almost cutting it out altogether, even as high up as the office of the Clerk of the Works, and within 100 feet of Carey Street. North and south sections in the vicinity of the axis of this swelling would show a very great diminution in the thickness of the ballast beds.

Close to the Strand this is not observed, owing to the entire absence of the gravels, but a section parallel to this and about 150 feet further northwards (see Fig. 2) shows the result of this roll on the ballast beds.

Fig. 2.



Length of section, 150 feet. *b* Gravels and Sands. *c* London Clay.

Here, between L and M, we have an extremely smooth slope of

* NOTE.—The 41 feet line represents the northern margin of the clay bench, as it would have to be indicated on a map of the surface, though actually 6 feet lower. The position and peculiarities of this bench are noteworthy, affording some insight into the relations of these gravels. Thus the Law Courts sections, though repulsive to the pure palæontologist, from the poverty and doubtful character of included remains (quâ gravels), may be of some service in other respects.

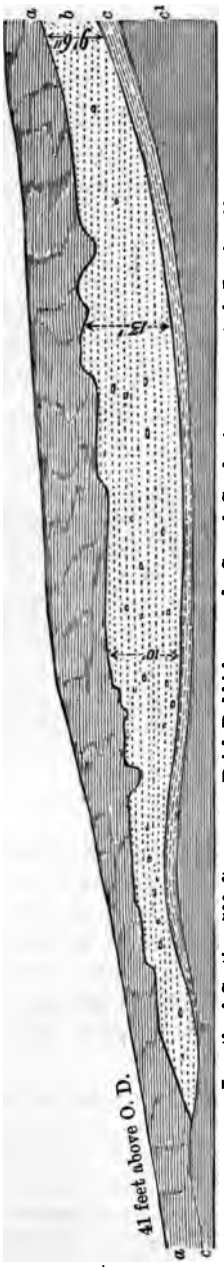


Fig. 3.
CLEMENT'S INN.

London Clay, which in one part has an inclination towards the S.E. of 1 in 11, or rather more than 5 degrees, with 10 feet of ballast at M and about 3 feet at L. Allusion will be made, subsequently, to certain peculiarities noticed in the gravels and sands of the deeper part of this section.

This swelling divided the works into two distinct systems of drainage; that towards the E. having its lowest level, as exhibited in Section No. 1, at about 100 feet from the southern extremity (this point is marked *x* in Fig. 4); that towards the W. probably at the S.W. corner of the area. The vertical scale is here also very much exaggerated.

Fig. 3 may be taken to represent a section parallel to the first, and at the opposite extremity of the area. The original surface slope is here more considerable; but here, also, we have the gravels and sands thinning out to a vanishing point, and the surface of the London Clay sunk as low as 31.5 feet above Ordnance datum line at the S.W. corner; in fact, so low that the basement is concreted on *Brick Rubbish* for a few yards at this particular spot. The sandy gravels further up the hill attain a depth of 13 feet, if the test-hole measurements are to be relied upon. They are more sandy on this side of the area. Not far from this line of section, and about 3 feet under

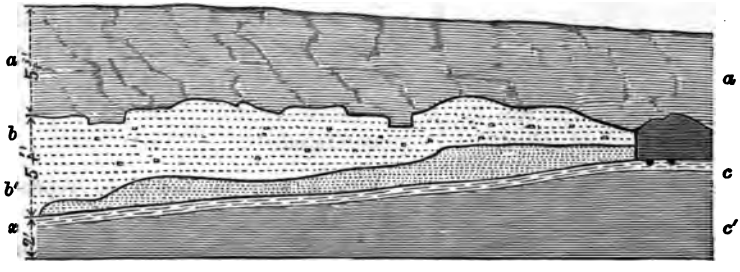
the sands, were discovered the horns of *Bos longifrons* and *Capra hircus* exhibited this evening.*

Special Sections.

Before attempting to institute any comparison between the beds exposed in this area, and those which rest on the London Clay (as ascertained from borings and other works), in various districts of the metropolis, it will be convenient to describe some special sections taken from actual observation during the progress of the works. These have been selected partly to shew the relations of the beds to each other in a given place, partly to exemplify the nature and mode of occurrence of the *sandy gravels* as evinced in certain spots, and partly to illustrate any local peculiarities worthy of notice.

Fig. 4.

N. Bell Yard. S.



Length of section 72 feet.

a Brick Rubbish. *b'* Yellow Sand.
b Gravel mixed with Sand. *c* and *c'* London Clay.
x Lowest depression of London Clay Surface.

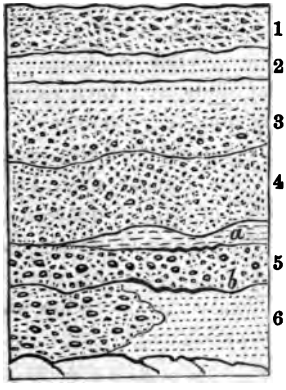
Fig. 4 is a section viewed from the floor of the excavation in the S.E. corner, and not far from Temple Bar. A portion of the Brick Rubbish on the surface may have been previously removed; but this is an exact representation of the appearance as seen from below. The upper surface of the gravel is, to a certain extent, indented by foundations, but otherwise wholly undisturbed. The length exhibited is 72 feet out of the 500 feet shown in Fig. 1 (the Bell Yard General Section).

* "*Bos longifrons* and *Capra hircus*." These are comparatively modern forms, and, according to Mr. Boyd Dawkins, not admissible into the true Post Glacial Fauna ("British Post Glacial Mammals," Quar. Journ. Geol. Soc., vol. xxv., p. 192). The latter species Mr. Dawkins considers to have been brought by man during the Pre-historic Epoch. The fact that these remains were found rather high in the ballast beds, points to the possibility of their having fallen through from some surface deposit of an age long subsequent to that of the gravels themselves.

It will be observed that in less than 70 feet the Sandy Gravels thin out from 5.25 feet to 2 feet, and then suddenly disappear. The point of their actual disappearance is concealed by a slip of brick rubbish, but a little further to the right this is seen to rest directly on the London Clay, with here and there what looks like a pocket or streak of gravel. It is always doubtful, however, so near the boundary line of surface accumulations, whether these pockets are natural or artificial. That they are natural is, however, highly probable, and that they present an important analogy with more recent phenomena will presently be shown. As before observed, the London Clay is cut away so as to slope from the line of the Strand, *i. e.*, away from the Thames. In 72 feet the surface falls from 4·5 feet above the floor to 2 feet above it. Northwards from the point *x* it begins to rise again. The gravels here observed seem to be an irregular accumulation of large and small sub-angular flints, mixed with some flint pebbles, and with reddish-yellow sands. In places a partial sorting of the materials prevails, and towards the bottom there is a distinct layer of fine yellow sand, which intervenes between the red clay and the other gravels; this seems to vanish towards the point *x*.

A more general, and, perhaps, more typical representation of the mode of occurrence of these sandy gravels is attempted in Fig. 5, which is a section of about 7½ feet of these "Ballast Beds," as they are called by the workmen. It occurs towards the N.E. corner, and, therefore, on the E., or Bell Yard side of the great swelling of the London Clay which runs through the area.

Fig. 5.



It must not be supposed that the actual demarcations are quite so strongly contrasted as here indicated; the changes from sand to gravel and from gravelly sand to sandy gravel being in some cases gradual, in others pretty sharp.

No. 1, then, represents layers consisting mostly of small fractured flints, interspersed with reddish sand.

No. 2 represents a mass of greenish sand almost entirely free from flints.

No. 3 represents a thicker mass of yellowish sand, becoming charged with flint gravel in its lower parts.

No. 4 represents a very pell-mell mixture of sandy gravels, which in the lower portions are remarkable as being smeared with a brick-red, sticky loam, forming a layer 2 or 3 inches in thickness.

a. Partially intercalated between these and the next beds, is a line of black sand, occurring as here shown. It is similar to others found occasionally in different parts of the ballast, as first pointed out to us by Captain Marshall Hall. The black colour is due to one of the higher oxides of manganese.

No. 5 represents a bed containing larger flints than usual; several of them oval and well polished, regular pebbles, in fact, such as occur in the Lower London Tertiaries, which are brought up to the surface in the N.W. corner of Kent, but must lie 150 feet below us here.

b. Here occurs a gravelly pocket, the individual stones of which are deeply smeared with black oxide of manganese. Immediately below the level of this

No. 6, a thick bed of greenish yellow sand, is seen to abut upon a bed consisting mostly of tolerably large sized flints and flint pebbles.

A few words as to the composition of the materials of these ever-varying Ballast Beds may not be out of place.

Mr. Prestwich has observed ("The Ground Beneath Us," Van Voorst, 1857, page 10, et seq.) that the gravels on Clapham Common, for instance, "consist of angular flints with their edges slightly worn, and of flint pebbles perfectly rounded, imbedded in a coarse siliceous sand, mixed with a small proportion of clay, and the whole coloured by the oxides of iron." He further alludes to the presence of chert, of a few large pebbles of whitish quartzite, of reddish sandstone, and of slate rocks. The flint pebbles are no doubt derived from the Lower Eocene beds. There occur, moreover, in these Ballast Beds, masses of a hard white sandstone, so compact as almost to resemble quartzite, one mass weighing probably not less than 3 cwt. We presume that these are "greywethers" or "sarsen stones," which Mr. Whitaker tells us (Memoir on Sheet 7, p. 72) are frequently found over the London Clay country, and therefore may be expected to occur in gravels resting on that clay, without having recourse to any extra mechanical agency to account

for their appearance in company with the smaller flint masses amongst which they are found. They usually exhibit, when found in this area, an irregularly angular shape, with the angles remarkably smoothed, very much like a block of rock-salt that has been licked by sheep. Mr. Whitaker is disposed to believe in their being derived from the Bagshot Sands, which would originally pass about 300 feet above the plane of this excavation. These masses must not be confounded with the quartzite pebbles which occur sparingly throughout the gravels.

As regards the finer materials, or sands, they vary in colour from brownish-red to reddish-yellow, yellowish-green and greenish-grey, and in size from extremely fine grains to a coarsish grit, the latter predominating. In the coarser sands the proportion of flint fragments increases, every gradation being passed through till we get to a sandy flint gravel. But whatever their colour, the ordinary sands consist of about 90 per cent. of rounded or subangular quartzose grains, a large proportion clear and translucent as rock-crystal, others of a semi-opaque amber-like appearance, with a few jaspery and calcedonic varieties. About 8 per cent. may be assigned to dark green bodies, occurring in oval, rounded, and reniform grains; and also, if it be really the same substance, in more or less angular fragments. These may be simply hydrous silicates of iron, or they may be fragments of a more complex pyroxenic mineral. In either case they may have been derived from the Greensand.

The general composition of the sands being similar, to what cause are we then to attribute their very considerable varieties of colour?

In the case of the black sands and gravels, this is most undoubtedly due to a black oxide of manganese, which is sufficiently plentiful as immediately to decompose hydrochloric acid in the cold with evolution of chlorine. It merely invests the grains and pebbles, being sometimes associated with a very fine clayey matter, and also more or less with ferric oxide. It is not clear whether the latter enters into composition with it as an ingredient of its mineral constitution, or is merely mixed with it. In cutting back the ballast further up the hill, these black-stained sands and gravels may be traced for a little distance, in some places thickening out to a pocket, in others thinning to a mere string. The origin and cause of this deposit of the manganese is worthy of investigation.

As regards its origin, it has been suggested that it may possibly have proceeded from artificial causes, such as old bleaching-works; the occurrence, however, is too frequent over the area for this to have been the case. Moreover, when there is a black coloration of the sands and gravels due to artificial causes, the colouring matter is much more likely to be black sulphide of iron. There was a good illustration of this occurring in the very thick Ballast Beds shown in section 2. These beds had been dug into to a certain extent previously. In one part, below a spot which the workmen declared to have been a cesspool, there was a great blackening of the sands, in appearance somewhat similar to the black sands just described, but the black colour was more diffused. Though so similar outwardly, the blackening of the ballast was, in this case, due neither to manganese nor to carbonaceous matter, but to *Protosulphide of Iron.**

Again, besides the bleaching-works theory, it has been suggested that these deposits of manganese are due to some sewage infiltration. We do not, however, see any reason to suppose that this is so. In all probability where there is a blackening from artificial impurities, it will generally be found due to this black sulphide of iron. This is the stuff that one sees in the vicinity of gas pipes; and singularly enough the modern beach of the Thames at low water, where there is a delivery of sewage, is largely charged with it.

A close investigation into the properties of this substance, which is also an artificial product of the laboratory, might throw some light upon the production and segregation of pyrites (bisulphide of iron)† in the various formations.

We may here observe that the entire absence of any noticeable

* That it exists as a protosulphide (the black hydrate, though probably of variable composition), we infer from the readiness with which it yields sulphuretted hydrogen to hydrochloric acid. The more soluble organic matters from this cesspool had passed through the porous sands during the period of its use, contributing their poisons to the waters, which percolated near the surface of the upholding clay. Clear and sparkling the liquid might appear when drawn from adjoining wells, but it doubtless proved a fatal draught to many a one who drank it. Besides these cesspools the fat churchyard of St. Clement Danes would further contribute to enrich the quality of the water in the lower wells. As an exemplification of this we saw two coffins drawn out of the bottom of a well adjoining this churchyard on the north side—just outside the Law Courts area. They must have been there for several years. In all probability the people who inhabited the house over it, drank of this water, charged as it must have been with organic matter of the most deadly description!

† Sulphide of Iron, FeS., black, soluble in hydrochloric acid.
Bisulphide of Iron, FeS_2, brass yellow, crystalline, insoluble in cold hydrochloric acid.
Magnetic sulphide, Fe^7S^8, often nickeliferous.

quantity of carbonaceous matter in the undisturbed portions of the Ballast Beds is remarkable.

Reverting to the manganese, certain planes of bedding are occasionally coloured for considerable distances, generally rather low down in the Ballast Series, and often underlying unusually ferruginous beds of it. The source of the manganese is either the London Clay itself, or else the dark green mineral before alluded to. As to the cause or mode of deposit, this we must look for in the perpetual running of water through the porous beds. Many streams were cut through in the course of the excavations, and it is probable that these streams occasionally changed their courses, widening out at times so as to pervade a bedding plane for considerable distances, and then perhaps escaping through a slight fissure into a more defined channel. These waters are charged at times with manganous and ferrous carbonates, of which the latter is more readily deposited, as a peroxide; hence the separation of the two.

There can be little doubt that to the percolation of water this phenomenon is due, and this may explain the fact of these black beds being rather more frequently met with in the lower portions of the Ballast. When the excavations commenced the lower portions were extremely full of water; these manganese beds appear to have been courses, where the water came "dribbling like," as we were told by one of the watchmen. A large catchwater drain is run along the whole of the north side of the area to intercept the subterranean streams coming from the unexcavated gravels to the northward. One of the effects of this has been to dry up the Lincoln's Inn pump.

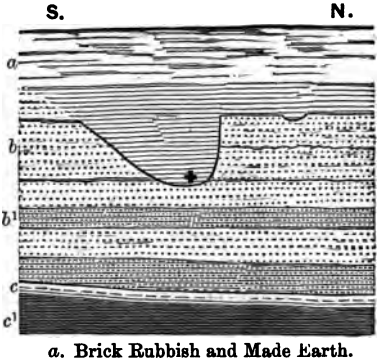
Returning now to the subject of the general colouration of the sands. This is undoubtedly due to the surface coating or spotting of the quartzose grains with ferric oxide in different states of hydration. It is observable that the yellower sorts are generally pretty clean, whilst those which have an ochreous smear upon them are frequently of a dirty brownish red. The greenish varieties have, in addition to the usual yellowish stain, certain dark green specks upon the grains of quartz. These appear like comminuted fragments of the above-mentioned green mineral, which also obtains in rather greater quantities in these varieties of sands.

We must refer again to the effect of carbonated waters permeating the loosely packed formation. These dissolve out salts of iron,

either from the surface of the London Clay at higher levels, or from the green mineral before mentioned. Air, at the same time, pervades the entire mass, oxygen is absorbed, insoluble ferric oxide is deposited, and the carbonic acid so liberated is ready for fresh work, perhaps to dissolve out some other matter in the formation. The reds, yellows, and browns, are probably due to different states of hydration of the ferric oxide. How these different states arise is too purely a chemical question to discuss here.

It may be noticed, in concluding this part of the subject, that the general appearance and shape of the grains of sand, especially of the finer varieties, is pretty much that of modern sea-sand, such as might occur on the beach at Brighton. The difference lies in the exterior coating. This circumstance, however, throws no light upon the mode of deposition of these beds, because whether fluviatile or marine, their contents (*quâ* sand) must be largely derived from the neighbouring Tertiaries, which themselves were derived in part from the also neighbouring Greensands. Beyond this point we need not pursue the investigation of their origin. Every time they changed their beds for a fresh resting place, these little grains of silica would be apt to have something taken off the angles, so that those which are roundest may perhaps lay claim to the most chequered existence. From what parent rock they were torn in the first instance, and how long ago, is a question which may never be solved.

Fig. 6.



a. Brick Rubbish and Made Earth.
b. Gravel. b^1. Sands.
c. & c^1. London Clay.

Fig. 6 is intended to illustrate a section occurring in the western part of our area. The excavation at this spot is 22ft., and shows

upon the surface several feet of brick rubbish, &c., resting towards the N. end upon gravel and gravelly sands, and on the S. upon vegetable mould, or made earth. This section plainly indicates that at some not very distant period there was a gravel pit here, though probably not later than the 16th century.

The gravel has been removed in one part to a depth of 12ft., the excavation inclining towards the S. until it thins out at the surface. When it was found necessary to level this ground (probably for building purposes), the void caused by the removal of the gravel was filled up with made earth, which contains the bones of recent animals, partially decayed, and bullocks' horns; these probably were the refuse of butchers' shops and kitchens. Amongst other things many shells of the common cockle and oyster were observed.

At the bottom of this pit, 12ft. from the surface (marked X in the Fig.) was found resting upon the gravel the calvaria of a human skull. This has been examined by Dr. Carter Blake, F.G.S., but unfortunately, owing to its fragmentary condition, he was precluded from taking any accurate measurements; so could simply come to the conclusion that it must have belonged to a large and extremely dolichocephalic individual of low type. How this human bone could have come into the place where it was found, we are at a loss to conceive, as no other human remains have been discovered, with the exception of a few skeletons which were found just below the surface in the brick rubbish. The owners of these bones, we conjecture, may have met with violent deaths, as this spot has been celebrated for centuries for the lawlessness of its inhabitants. There is no doubt that this calvaria is of considerable antiquity, as the animal matter is almost entirely absent from it.

The gravels immediately underneath the spot where this bone rested are sandy, and intermixed with subangular flints, with here and there a pebble, similar to those already described as occurring upon the E. side, without, however, just here exhibiting any stains of manganese. At a distance of about 15 feet eastward from the sections described, and lying about 3 feet from the top of the Ballast Beds (here very sandy), were found the horn cores of *Bos longifrons* and *Capra ægragus* (*C. hircus*, Linn).

In the sandy gravels at the N.W. corner of the excavation, and at a depth of about 7 feet from the surface, another horn core of a *Bos* was found. This specimen, which, unfortunately, is broken into two pieces, was shown to Mr. Davies, of the British Museum,

area; at B there is a sort of choke, where a reddish sandy clay, almost free from flint, is very closely encroached upon by the sands on either side. There then occurs a sort of expansion of the mass, into *c*, also a reddish sandy clay, which terminates in a thread, not a quarter of an inch thick, running down into the basement clay. For geological purposes, it would perhaps be idle to speculate on the causes of this appearance, which has very likely an artificial origin.*

We have inserted this section principally to illustrate how easily an error might occur in estimation by borings. So that other causes, besides mere carelessness or actual inaccuracy, do contribute to the uncertainty attendant upon these when within short distances of the surface. In another part of the works there is a regular dyke of this stuff, 66ft. long by 8ft. wide, at the broadest end. It must surely be artificial.

The fossils of the London Clay were not so numerous in this area as we expected, and most of them were very much pyritized. In many instances the clay had become so mineralized that it was impossible to assign them to any genus, much less to a species.

The following is the list of fossils obtained :—

Lamna elegans. *Ag.*
Goniaster Stokesii. *Forbes.*
Nautilus.
Triton Morrisii, Edw. *M.S.*
Pyrula Smithii. *Sow.*
Fusus bifasciatus. *Sow.*
„ nitidus. *Hudleston & Price.*
„ sp. (a cast.)
Cassidaria striata. *Sow.*
Pleurotoma stena. *Edw.*
„ varicosa. *Hudleston* and *Price.*
„ helix.
Voluta Wetherellii. *Sow.*
Cypræa oviformis. *Sow.*
Natica labellata. *Lam.*
Cerithium Charlesworthii (?).
Aporrhais Sowerbyi. *Mantell.*
Dentalium anceps. *Sow.*
Solarium patulum. *Lam.*
Arca impolita. *Sow.*
Avicula papyracea. *Sow.*
Nucula Bowerbankii. *Sow.*
„ sp.
Cryptodon angulatum. *Sow.*
„ Goodhallii. *Sow.*
Syndosmya splendens. *Sow.*
Teredo antenautæ. *Sow.*

Flint casts of *Micraster cor-anguinum*, *Ananchytes*, and *Ventriculites* were found in the gravels.

Besides the above, we found a *fruit-stone*, which was shown to Mr. Carruthers, F.R.S., of the British Museum, who stated that it appeared to him to be the stone of a Drupaceous fruit, and is un-

* Mr. Lett informs us that the saddle of clay had extended for some distance N.W. and S.E. It excited his indignation as being the most "useless stuff he ever set eyes on;" no good for brickmaking, no good for ballast, a dead loss, in fact, to the contractor.

described by Bowerbank, and, as far as he knew, by any other author.

It will be well to bear in mind that the horizon is 300ft. below the top of the London Clay, as exhibited in the Highgate area, and this may account for so few fossils being discovered.

Conclusions.

It only remains for us now to make some attempt to compare these gravel beds with others in and about London.

For this purpose it may be well to bear in mind that the floor of the beds in the lower parts is about 33 feet above Ordnance datum line (where unaffected by any great swelling), and about 44 feet above it in the upper part of the area, and that a bench of uncovered clay cuts them off on the south or towards the Thames.

The Ballast Beds belong to the great *West London Block*. This is bounded on the S. by the tongue of London Clay, which is a continuation of that in the Serpentine valley, and more especially of that which occurs on the western escarpment of Campden Hill, and thence passes below the line of Piccadilly, and is, we believe, continued along the Strand, and possibly through Fleet Street, till it strikes the Fleet valley, which is the eastern boundary of the block. On the north its boundaries are not defined by any valley, the London Clay continuing to rise in this direction. The general plateau of this mass is between 80 and 90 feet above Ordnance datum; though at the N.W. extremity it rises much higher. Our area is on the S.E. slope of the block, and may be described as belonging to the riparian portion of it. By the term "riparian," we mean that part of the sloping gravel sheet which is comprised between the often-mentioned bench of clay and the edge of the plateau, *i. e.*, speaking roughly, between the 40 ft. and the 70 ft. line.* We have seen that in no place has the pure gravel a thickness of more than 13 feet, and if we add 6 feet for brick rubbish, the maximum of superficial deposit is 19 feet. This is exactly the depth given for similar deposits at Meux's brewery, which is about 85 feet above Ordnance datum, and may be con-

* It is worthy of remark in connection with this subject, that between these limits on the northern slope of the Thames Valley, the gravels have as yet yielded no certain traces of Man, and but rare and doubtful indications of Post-glacial Mammals. The flint implements found recently by Col. Lane Fox at Acton (Quar. Journ. Geol. Soc., vol. xviii, p. 449) were mostly about the 80 ft. (surface) line. The one at Grays' Inn would perhaps be about the 70 ft. line. On the other hand the rich finds of mammalian remains have been in the lower gravels and brick earths, the Mid Terrace Gravel of Whitaker and Fox.

sidered as on the plateau. Smith's distillery at Covent Garden, nearly on the same level as the Law Courts, 25 feet. A well near Golden Square gives 10½ feet gravel, but does not state the amount of brick rubbish.

The following borings along the line of the Middle Level Sewer also belong to this part of the western block :—

	Surface.	Ballast.	Total.
N.E. corner of Lincoln's Inn Fields . . .	8	11¼	19¼
Corner of St. Martin's Lane and Long Acre . .	13	1½	14½
Regent's Circus, Piccadilly	10½	6¾	17¼

Now we would wish to invite comparison between these very moderate thicknesses of gravel, as exhibited on the southward slope of the western block (where also the surface of the clay base is very irregular), and the much greater depths of gravel which obtain in the lower levels of the metropolitan area.

	Surface.	Ballast.	Total.
South Kensington (Horticultural Society's Garden)	18	22	40
Battersea York Road			32
Old Pye Street			30½
Simpson's Factory, Pimlico	7	19	26

This latter is 13½ above Ordnance datum, hence the clay is reached at 12½ below that level.

These give us something like a mean of 20 ft. of gravels alone, being at least double of what we see in the western block of riparian and plateau gravels, and nearly three times the mean depth of the Law Courts gravels. Again there is a marked contrast in their position and mode of occurrence. In the recent excavations at Battersea (see paper by Mr. John A. Coombs, page 33) we noticed on the whole a more even bedding, smaller size of flints, and certainly a less deeper stain from oxide of iron. This latter circumstance may partly arise from the immense quantity of water which those beds hold, the upper beds even being below high water mark of the adjacent Thames. In the very deep cutting on the Metropolitan District Railway, between Gloucester Road and Kensington High Street, the gravels are small, sandy, and cross-bedded.

In conclusion, we should endeavour to ascertain how far the present operations of the existing river in the immediate neighbourhood of London are producing effects similar to those we have attempted to describe.

The modern Thames has cut its way through the Lower Level

Gravels down to the London Clay, but what is it doing by way of deposit? Let us take as a specimen the line of the embankment wall, now in course of construction along the north shore from Chelsea Bridge to the new Albert Bridge.

The excavation for the foundation of the wall runs along the edge of the beach at about the margin of ordinary low water. For a large portion of the distance there is not much more than 1 foot of extremely coarse gravel above the clay. Here and there occurs a pocket of some 3 feet of ballast, but this is an exception. A thin smear of "Battersea Butter" frequently just coats the surface. Here we have an appearance very similar to that which occurs at the S.E. corner of the Law Courts excavation, where circular pockets of red ballast have been mentioned as not unfrequent on the top of the clay bench so often alluded to. Indeed, the appearance is so similar as to suggest the probability of this clay bench representing the average low water line of the river or estuary of the period throughout a considerable lapse of time.

The excessive thinness of the river gravels along this line may be attributed to the wash of the tide at low water. A few yards further in the stream, where the cylinders of the Albert Bridge are being fixed, there is 4 feet of coarse ballast resting on 1 foot of fine ballast before the clay is reached. A section here (taking Trinity High Water Mark as the surface) gives—

Water	22ft. 6in.	
Coarse Gravel	4ft.	River Bed, Chelsea, North shore.
Fine Gravel	1ft.	
London Clay		

At the Cylinders on the south side we have a greater deposit.

Water	15ft.	
Coarse Gravel	10ft.	River Bed, Battersea, South shore.
Fine Gravel	1ft.	
London Clay		

In the distance, between the two sets of cylinders (= to rather more than half the width of the Thames), a slight rise of the surface of the London Clay towards the south is established. It would seem to be about 1 foot.

Proceeding from low water mark in an opposite direction, *i. e.*, away from the centre of the river, we also find the modern deposits thickening to the depth of several feet until they finally mix with the finer and more sandy beds of the Lower Level Gravels. At a distance of about 120 feet from low water mark, this beach

deposit of the existing Thames, mixed, probably, with a portion of the older beds, attains a depth of 17 feet, if not more, of which 5½ feet is black and contaminated, and 11½ feet red gravels and sands, containing remains of small oxen and of red deer in considerable abundance.

Taking another part of the river nearer our area, we find at Westminster Bridge (on the authority of Mr. Bryant) that there is about 3 feet of coarse ballast in the centre, with from 7 feet to 10 feet along the north shore. At Blackfriars, about 3 feet in the centre, and just opposite the entrance of the Fleet, we have 12 feet of ballast resting on an accumulation of silty mud.

This latter circumstance tends to show that in certain bights of the river a considerable depth of ballast may even now be accumulated under favourable conditions, though the general deposit of the modern Thames bed is scanty where the current is strong. The quality is certainly coarse, and the fragments larger than those of the Lower Level Gravels through which the bed is cut. This may be the result of a stronger sweep of tide through narrowing of the channel. In the Law Courts area, where the gravels belong, we presume, to the riparian portion of the Upper Level Gravels, the fragments, as before noticed, run larger than in the lower beds, and, in this respect, more nearly resemble the ever-shifting deposits of the modern Thames.

Description of New Species.

1. Pleurotoma varicosa.—This Mr. Etheridge, F.R.S., considered new to Britain. It was very numerous in the deepest parts of the excavations. Shell elongato-fusiform, whorls five, convex, transversely striated, having varicose longitudinal costæ, which gradually fade away on the body whorl before reaching the canal, aperture ovate. This shell we name provisionally, as it may have been figured by foreign authors.

2. Fusus nitidus.—This specimen was shown to Mr. Etheridge, F.R.S., who pronounced it to be probably new to England, and also probably figured, but not yet named by Mr. Edwards. We only obtained one specimen of this fossil. *Description*—Shell ovato-fusiform, transversely striated, whorls five, convex, sutures distinct, aperture ovate. This we also propose to name provisionally, *i. e.*, subject to its not having been named by any foreign palæontologist.

1. Pleurotoma varicosa. *Hudleston & Price*
2. Fusus nitidus. *Hudleston & Price*.

C.L. Griesbach lith. Mintern Bros. imp.

NEW SPECIES OF GASTEROPODA FROM THE LONDON CLAY, STRAND.

EXCURSION TO WATFORD,
April 13th, 1872.

Directors:—William Whitaker, Esq., B.A., F.G.S., of Her Majesty's Geological Survey, and John Hopkinson, Esq., F.G.S.

(Report by Mr. Hopkinson.)

A numerous party of ladies and gentlemen assembled at Watford Station at three o'clock, and proceeded northwards along the main line of the London and North Western Railway, under the guidance of one of the Company's Inspectors, to the cutting leading to a tunnel which is now being constructed to take two additional lines of rails. The new cutting, which diverges slightly from the old one at about half a mile from the station, exposes a section of the Chalk overlaid very irregularly by a thick bed of gravel, composed of sub-angular flints derived from the Chalk; of rounded flint pebbles also originally derived from the Chalk, but owing their present form to the attrition they have undergone in the older Tertiary rivers and seas; and of pebbles of very ancient rocks, some of which again were not originally derived from the parent strata, but from the conglomerates of the New Red Sandstone. Here and there also, in the gravel, more or less regularly stratified beds of sand, divided by layers of pebbles, are seen.

Before leaving this section Mr. Whitaker explained, in a few words, some of the chief features of this gravel, which he considered to be of "Middle Glacial" age, and referred to a few of the most interesting problems connected with it. He stated that although we have in the section here exposed no certain data to determine the age of the gravel, we find elsewhere lying upon it patches of Boulder Clay, showing that as this gravel was deposited before the Boulder Clay or "Great Glacial" period, the Chalk, which here was originally some 100 feet (or more) thicker than now, was denuded to this extent before, or during, the Boulder Clay period. The sub-angular flints were not considered to have been derived from the chalk upon which they immediately lie, but to have been drifted, most probably partially at least by the action of ice, from other localities, being here deposited, together with the Tertiary flint pebbles, and the pebbles of quartz and other rocks ice-borne from the conglomerates of Worcestershire and Warwick-

shire, in shallow water where the currents were shifting.* After the chalk had been, as it were, planed down to its present thickness, the gravel was deposited pretty regularly upon it; the present uneven surface being in great part due to the dissolving away of portions of the chalk by the percolation through the overlying porous bed of water charged with carbonic acid, the carbonate of lime being carried off in solution as a bicarbonate. Thus are formed in the Chalk what are called "pot-holes" or "pipes." Wherever the water can get away, as through cracks in the chalk, it is evident that this decomposition will take place, the gravel sinking into the hollows thus formed.

At the conclusion of Mr. Whitaker's address, of which the above is but a brief summary, the party left the cutting at the mouth of the tunnel and proceeded direct over the old tunnel and through the woods to Cassiobury Park, entering through the nearest private gate, permission to pass through the private grounds of the Earl of Essex having been received through the kindness of Mr. C. F. Humbert, F.G.S.

In the park carriages were waiting to convey the ladies to Watford Heath, a distance of three or four miles, and the rest of the party took the nearest path across the park and over the fields. On re-assembling at Watford Heath Kiln Mr. Whitaker described the section there exposed, and a few fossils were found; Mr. W. T. Stone, the owner of the pit, also very kindly distributing several fossils which he and his workmen had obtained. These principally consisted of shark's teeth, which occur in considerable abundance in the upper of two pebble beds forming part of the Basement-bed of the London Clay; a few only being found in the lower bed. There were also a few oyster shells which are here only known to occur in the lower pebble bed.

Since this section was last visited by the Association† a well has been sunk through the Woolwich and Reading beds to the Chalk, just on the edge of the Mottled-clay, which here ends abruptly, its place being taken by the bed of sand on which it rests; the Basement-bed reposing in one part of the pit immediately on the Mottled-clay, and in another on the sand.

After a short walk across the fields, Bushey Kiln, the last section

* The presence in these Post-Pliocene gravels of the remains of some animals indicating a warm, and others an arctic climate, renders it probable that they were not entirely deposited by the agency of ice.

† For a description of the section, see Proc. Geol. Assoc., vol. ii., page 43.

visited, was reached. The chief point here noticed was the great difference of the section of the Woolwich and Reading beds from that exposed at Watford Heath, showing how very irregularly these beds were deposited. A small section, exposing several layers of pebbles in sand, showed how this difference might be partly accounted for. Not only were these layers very irregularly distributed, but between each more or less horizontal layer were to be seen thin connecting layers of pebbles passing through the sand at various angles, showing how, subsequently to the deposition of each layer of sand, strong counter currents tore up the underlying pebbles and redeposited them at various angles. So it is, and so we should expect it to be in fresh water or estuarine strata—here sand deposited, there pebbles—at one place clay, at another loam. How very different this from the uniformity over large areas frequently presented by marine strata, such as the London Clay above, and the Chalk below.

On arriving at the Bushey end of Watford the party separated, some walking to Watford Station to catch a quick train to London, and others leaving by a later train from Bushey Station.

EXCURSION TO HAMPSTEAD,

April 27th, 1872.

Directors:—S. R. Pattison, Esq., F.G.S., and Caleb Evans, Esq., F.G.S.

(*Report by Mr. Evans*).

A considerable number of ladies and gentlemen assembled at four o'clock in the afternoon at the Swiss Cottage Railway Station, and proceeded to examine the geological character of the neighbourhood of Hampstead.

On reaching the fields by the shaft of the Midland Railway tunnel near Belsize Lane, Mr. Pattison addressed the party and explained that the lower parts of the district consisted of the stiff clay known as the London Clay, and that the upper part of the hill was composed of sand, which was an outlier of the lower part of the Bagshot Sands of Surrey. This porous sand acted as a kind of sponge and the water which percolated through it, being upheld by the impervious London Clay below, appeared as springs on the

shire, in shallow water where the currents were shifting.* After the chalk had been, as it were, planed down to its present thickness, the gravel was deposited pretty regularly upon it; the present uneven surface being in great part due to the dissolving away of portions of the chalk by the percolation through the overlying porous bed of water charged with carbonic acid, the carbonate of lime being carried off in solution as a bicarbonate. Thus are formed in the Chalk what are called "pot-holes" or "pipes." Wherever the water can get away, as through cracks in the chalk, it is evident that this decomposition will take place, the gravel sinking into the hollows thus formed.

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sides of the hill. These springs served as a good indication of the junction of the two formations.

No animal remains (with the exception of a few casts of shells and some rare indications of fishes) have been obtained from the Bagshot Sands in the London Tertiary area, but in Sussex the Bracklesham Beds—the equivalent of a part of these sands—contains a very varied fauna, which is perhaps only exceeded in richness by that of the Calcaire grossier of the Paris Basin, a deposit of probably the same age. Equivalent strata are also seen at the Hill of Cassel in the North of France, from which spot Mr. Pattison had obtained *Cerithium giganteum* of large size.

Mr. Evans then, with the aid of sections and a large geological map of Hampstead, explained the local details of the Geology of the district, and stated that the stiff London Clay passed in its upper part into a sandy clay which surrounded the hill at a definite level. Fossils were very abundant in this sandy clay, especially *Pectunculus decussatus* and *Voluta nodosa*. These shells had been obtained from the spot where the visitors were then assembled, the lower part of this stratum having been traversed in the shaft of the Midland tunnel.

The party then proceeded to the Conduit Spring, which indicated the presence of the Lower Bagshot Sand, and by the aid of an aneroid barometer it was shown that the "Pectunculus-bed" was about 50 feet in thickness.

The drains in course of construction in the Greenhill Road exposed a good section of the sands; and the party then followed, as nearly as possible, the line of junction of the sand and clay, which was indicated by pools of water in Gayton Road, the chalybeate spring in Well Walk, and the springs by the pond at the Vale of Health.

At this spot the Members were considerably increased by the addition of gentlemen, who, under the conduct of Professor Tennant, had visited the residence of Lady Burdett Coutts at Highgate, and had inspected the fine collection of minerals in the possession of that lady.

The character of the valleys, which were here observed to radiate from the central plateau of sand, was noticed, and the party (now numbering about 50) ascended to the higher ground, and examined the sand there exposed in pits.

In the large sand pit on the top of Hampstead Heath, opened a

few years since for the purposes of the Midland Railway, attention was particularly directed to the gullies or small ravines which had been excavated since that time by the action of the rains falling on the surface and percolating through the porous deposit until checked by the thin bands of sandy clay which are interstratified with the sands. It was suggested that these ravines furnished an illustration of the process by which the diverging valleys around Hampstead had been formed.* It was also suggested that the rounded flint pebbles, scattered over the surface of the heath, might be the remains of higher strata, which had been removed by the gentle but powerful action of subaerial denudation.

From the Mound, near North End, the Geological character of the country to the north was explained. The high range of hills by Bushey and Elstree forms the northern escarpment of the London Clay, and the intervening range of hills by Hendon and Finchley is capped by Glacial clays and gravels resting on an eroded surface of the London Clay.

On the West Heath the position of the junction of the Bagshot Sand and the London Clay was again seen, and the spot, by the Leg of Mutton Pond, where *Pectunculus decussatus*, &c. had been obtained during drainage excavations was pointed out.

In order to afford the Members an opportunity to observe the effect produced on the surface by the superposition of the water-bearing sand above the London Clay, they were then conducted across the swamp which occurs in the lower parts of the West Heath Valley.

The party then proceeded through High Street, Hampstead, to the residence of Mr. C. Evans at Downshire Hill, where the major part inspected that gentleman's collection of Tertiary fossils; some of the choicest specimens of which had been obtained from the immediate neighbourhood of Hampstead.

* See Proc. Geol. Assoc., vol. iii., p. 31.

ORDINARY MEETING, May 3rd, 1872.

James Thorne, Esq., F.S.A., Vice-President, in the Chair.

The following Donations were announced :—

"On the Relative Ages of the Stone Implement Periods in England," by J. W. Flower, F.G.S., from the Author.

"Abstracts of the Proceedings of the Geological Society," from that Society.

"Miners' Association of Cornwall and Devonshire—Annual Report for 1871," from that Association.

The following were elected Members of the Association :—

Arthur Angell, Esq.; H. George Fordham, Esq.; William Henry Hennah, Esq.; Henry Hobden, Esq.; John Studdy Leigh, Esq., F.G.S.; Reginald John Gilbert Leigh, Esq.; Arthur S. Lovelock, Esq.; A. R. Montalba, Esq.; and William Taylor, Esq.

The following Papers were read :—

1. On a Visit to the Diamond Fields of South Africa, with Notices of Geological Phenomena by the Wayside.

By John Paterson, Esq., M.A.

(*Abridged.*)

Though the paper I have undertaken to read this evening may be less of a scientific character than those to which you are accustomed, yet, as as a contribution to the information concerning Diamond Land, it may not be unacceptable to this Association.

You wish to know something more of that country—to hear something more of the wonderful discovery of diamond-fields there—to look in upon its scenes through the eyes of a visitor, if I may so say, without encountering all the heat, dust, and other discomforts of a personal visit, and happy should I be could I this evening meet your desires; but I scarcely know how I should best help each one, for himself and for herself, to realize that wonderful scene of diamond-land in South Africa. Should I describe to you its already explored extent—over 10,000 square miles—within which at many different points diamonds in great numbers have

already been unearthed; or should I tell you of the richness of the finds in certain favoured and congenial spots where, as at New Rush, from an area of less than half a mile square, diamonds to the value of over one million sterling have already been extracted; or should I paint to you something of the living moving scene there, where in each little space of 30 feet square—called a claim—there are 10, 20, 30, or even more, busy diggers at work in search of the precious gems; or should I speak to you for a little of the delightful climate of that bright land, whose deep blue heavens are studded with so many starry brilliants—brilliants of stars which, seen through the clear atmosphere of South Africa, seem like innumerable gems of glory fresh cut and fresh polished from the hands of the Great Artificer himself; or, returning again to this nether world, should I picture to you something of the wooded plains around that scene, and the terribly impressive solitudes, and the simple primitive pastoral life of the few early indwellers there; or, descending still deeper down among nature's crypts, so to speak, where she has laid the sure foundations of this grand old temple of God's praise named Earth, interrogate there the molten rocks and silent shales in your hearing that they might be moved to tell us, in the signs and hieroglyphics of some strange remains in them, something of their long bygone history,—all these things and much more should I have to do before I succeeded in making you realize in full, that wonderful magic scene, as I may term it, which Diamond-land in South Africa now presents.

We first enter that country at a small town called Fauresmith, 350 miles due north of Port Elizabeth. I ask you to join me there, and to look abroad with me upon the surrounding scene. The country for many miles around is one extended plain, or great table-land, some 4,000 to 5,000 feet above the level of the sea. It is reached by one almost continuous ascent from Port Elizabeth, through a country much more broken in surface, and known among geologists as the great lacustrine country of South Africa. This region is supposed once to have been the bed of a great inland lake, the waters of which had, under some great convulsions, burst their way by several channels through the enclosing mountain ranges, and fled to lower levels in the existing seas. The country at least is marked and scarred in every direction by deep traces of some violent agency, but these traces almost entirely disappear as you enter Diamond-land. You see no more the gashed and torn

mountain sides, the bare and blasted peaks and headlands, the deeply worn and furrowed plains, the great upheaved and twisted quartzite ranges leaning on mighty axes of porphyritic rock, by which they have been upborne, but a country in oppressive repose and sameness, if one may so say, in which the wide extended plains after plains, or "flats" as they are termed, seem never to have been subjected to any more violent action than is expressed by ever-recurring ridges, sometimes only a few feet high, sometimes a few hundred feet high of the prevailing trap-dykes of this region. These trap-dykes are a very marked feature of diamond-land, and the FIRST feature to which I desire to call your special attention.

The SECOND striking geological characteristic of the region is the vast breadth of shale formations reaching out in every direction, now the yellow ochreous shale, then a bluish slatey shale, and again a dull, black carboniferous shale. These extend in undisturbed horizontal position for miles and miles, unless where they are ever and anon seamed and riven, and occasionally slightly tipped from their horizontal position by the protruding dykes of trap to which I have just referred.

A THIRD feature in the scene to which I would just desire to draw your attention is the " sacked " or sunken appearance, as one may term it, which each vast plain or flat presents, as if towards its centre it had settled down from the level of the trap-ridges which traverse them from N.E. and S.W. How this appearance has been imparted to the scene, perhaps, it would not be very easy to say, but where such uniformity of effect has been produced, it may be assumed to have been the result of some single uniform commensurate force within. Can it be that these wide-spread shales have in some by-gone age been swayed and rocked upon a molten liquid mass or portion of themselves beneath, which by the earth's motion on its axis, or kindred cause, has ever and anon rent the unmolten crust above, and projected through the numerous seams or lines of division so caused in it waves of molten trap or greenstone from the liquid mass below ? The strange depressed flats of Griqualand suggest such an idea, and the injected traps of greenstone seem in their elements of composition none other than the molten shales of the country.

A FOURTH feature which I would desire to notice here before descending to more minute and detailed examination of our subject is the peculiar resemblance of the shale formations of Diamond-

land to a section of the deposits of modern lagoons, as if the Diamond-land had been once a great lagoon like Lake Nganii, in which reeds and grass and matted weeds of every description grow up in greatest rankness, and with every succeeding flooding of rivers or streams pouring into it, are buried in endless layers of slime and clay until they constitute a body of shale like that which is cut through at so many points by the Vaal. The carboniferous shales especially are clearly the product of reeds and grasses such as grew in a lagoon, and were laid down from time to time in the mud and sediment of inflowing waters.

Bearing these points or general features in mind, let us now visit in company together the first diamond diggings of Griqualand. They are situated at a place called Jagers Fonteyn, about an hour on horseback from the little town of Fauresmith. The road to these diggings is across a country of dull grey shale, and the diggings themselves lie in a hollow enclosed on every side by dykes of trap. Let me now detail to you the appearances which struck myself most forcibly when lately I visited these diggings, and here I call your attention—

First to the *stuff* which the diggers were excavating from the pits. It consisted of a kind of marl, or mixture of lime and clay—whitish by the presence of lime in it, when first dug out, but soon under exposure changing into a greenish tinge approaching that of olivine in some trap rocks. The same marl I found at all the diggings, and soon had forced upon me the conviction that it was the matrix soil of the diamond.

The second thing that struck me at these diggings was the peculiar character of the trap rocks by which they were enclosed—a trap of greenish tinge when fresh broken, but soon, under exposure to the winds and rains, rusting or wasting away into a red unctuous dust.

A third singular and remarkable appearance which struck me as I explored these diggings was the amorphous condition of the marl-stuff which was being excavated from the claims or pits. It showed no regular formation, but was ballasty, so to speak, in appearance, and seemed such a mass of nodular lime and clay as is produced where with hot water a mortar of lime and clay is made, and thrown up in a heap and there allowed to dry.

A fourth, and I may add, last feature of the diggings here which struck me, was their situation. Surrounded on every side by a

ridge of trap rising to some considerable height above the surrounding country, the marl there enclosed could never have been lifted into that situation by water agency. It was stuff *in situ*—at least ever since the trap-dykes had been raised around it.

A few smaller points of observation I also noted down carefully here, such as that the nodules of marl were very friable to the touch, that subjected to a running stream of water they readily dissolved, and so could never have been a vehicle for the bringing of diamonds from a distance by any torrent or stream; and finally that from this marly stuff many crystals and siliceous nodules were being sifted. I noticed nothing further in any way peculiar or deserving of particular attention here, and so left Jagers Fonteyn, bearing carefully with me in memory the appearances and facts I have just detailed. The next diggings to be visited are the Koffy Fonteyn diggings. Here too you meet at the edge of the diggings the greenstone trap, exactly in texture and colour, as well as ingredients, the same as the traps around Jagers Fonteyn, and related in the same way to the enclosed diggings.

Nor did the points of similarity end here. If the marl into which the diggers were working at Jagers Fonteyn were an amorphous mass, as if all texture in them had previously been destroyed by fire or by water, or by both, so was the stuff here. If at Jagers Fonteyn you looked in vain for traces of fluvial deposit, or of deposit by some mighty torrents, so, too, you looked in vain here. If at Jagers Fonteyn you could discover no higher source for the diamonds found there in any proximate mountain chain, so here too the theory of such an origin broke yet more fatally down, for no mountain range whose detritus could have been strewed there was within a hundred and fifty miles of the spot where now we stood. And finally if even such a distant origin could be supposed, the question rose, in very insoluble form to my mind, by what doctrine of chances is it to be explained, that the diamonds brought from afar across these plains should, like living things of instinct, here, as well as at Jagers Fonteyn, seek the identically same marl stuff as cover, or their hiding place, so to speak. The affinity between the marl and the diamond was not to be disputed; but was it an affinity of some magnetic attraction, by which they sought each other from afar? I leave you to take with you this question, while we now proceed on our journey to the greater diggings of Du Toit's Pan, of Bultfonteyn, of Colesberg Kopje, and Old De Beer's.

These diggings are distant from Koffy Fonteyn about sixty miles, and the road lies across the ever self-repeating flats, as they are termed, of Griqualand West. In crossing these great flats one or two geological points struck my attention. I have already observed to you how these flats "sacked" in builders' phrase, or were slightly sunk towards the centre from the higher level of the crossing dykes of trap, which in such numbers traverse the extended plains, and seem to act there like great joists thrown in by nature to support the vast floor of shales across which we drive. This sacking was clearly an inclination to the trap dykes, and indicated beyond dispute that the traps were rocks of more recent origin than the shales, and by their intrusion had disturbed the older stratifications. The shales were there seen to be disturbed by them, and if in the traps there are found unfused substances common to them with the shales, such as garnets and spikes of olivine, these substances it may be assumed, I think, the traps have received from the shales in their upward eruptions through them, and not that the shales received these substances from the rusting away and waste of the intruded traps.

Another point of geological interest which struck me forcibly as I crossed these plains, was the constant recurrence, in patchy deposits of no great thickness, of an effloresced tufa or limestone. These patches had a very peculiar appearance, and looked like a lighter scum of limey impurity boiled up from beneath upon the surface, as the scum of dross is boiled up upon and out of the molten metal. It was observeable too that these patches ever lay near a crossing dyke of trap, and seemed to have in their origin some relationship to it.

A last point which distressingly impresses itself upon the traveller across these flats is the frequent occurrence of great drifts of that reddish sand, as they call it, or rather dross of iron-clay, which makes the roads through it so heavy to the horses. This red powder is undoubtedly derived from the rusting away of the ridges of greenstone-trap under exposure to the weather, and goes on in very rapid decay. A fresh broken piece of greenstone-trap, green when so broken to the deepest tint of olivine, will, if blown upon by the winds and rains, within a month begin to cover itself with its own reddish rust, and I think it important to take note of this here, for I am not sure that to the composition, the peculiar composition of the traps of Griqualand, in

which iron and olivine are so richly present, something of their metamorphic power upon the surrounding shales may not be due.

But it is perhaps time that we should cross the intervening flats, follow the busy crowd to the scene of their labours, and observe the operation of diamond-finding, say at Colesberg Kopje or New Rush, as it is called.

The New Rush diggings are all going forward in an oval space enclosed around by the trap-dyke, and of which the larger diameter is about 1,000ft., while the shorter is not more than 700 feet in length. Here all the claims of 30 feet square each are marked out with roadways of about twelve feet in width occurring every sixty feet. Upon these roadways, by the side of a short pole fixed into the roadway, sits the owner of the claim with watchful eye upon the Kafir diggers below, who fill and hoist by means of a pulley fixed to the pole above, bucketful after bucketful of the picked marl stuff, in which the diamonds are found.

Many of the claims are already sunk to a depth of 100 feet, and still, as plentifully as ever, the diamonds continue to be found. From the roadway above, the marl is carted away to the sorting tables outside the range of the diggings among mounds of marl stuff which seem like little hills. Here amidst such whirls of dust as are nowhere else seen, the marl stuff is pounded, sifted of the finest powder of lime and clay, and from the residue put on the sorting tables, the diggers, with a piece of zinc 9 inches long by 4 inches in breadth, search out, in the successive layers taken from the heap, the precious gems. I need not tell you that the search is by no means very perfect, or that perhaps as many diamonds escape the digger's eye as are discovered and taken out by him, but you will perhaps confess with me that their aptness in picking out the diamonds is by no means to be despised when I tell you that in one six months from the date of opening New Rush diggings little short of a million sterling in diamonds has been extracted from them. At close of day the diggers take daily stock of their finds, and between five and six o'clock in the afternoon are to be seen hundreds and hundreds moving through the main street of New Rush in visits to the tents of the buyers, seated behind their little green baize tables with scales all ready, and bags of gold and silver, and piles of bank notes to buy the little gems.

Whilst I was at Du Toit's Pan diggings, the spectacle of the diggers working through the fragments of unchanged shale at some

points only a few inches in thickness, at some points from 3 to 4 feet in thickness, sufficiently impressed me to make me revolve the point, while I made my next visit to New Rush, scarcely two miles distant.

Here I had scarcely arrived, when a feature yet more striking than the fossil shale of Du Toit's Pan presented itself to me in a black heap of true carboniferous shale being dug up by some well-sinkers in the very midst of the mounds of greenish marl around the New Rush claims. These well-sinkers were excavating a pit in search of water just outside the "reef," as it is called, of greenstone trap, which encloses New Rush diggings, and from this pit down to a depth of 60 feet, were bringing up bucketful after bucketful of black carboniferous shale in strata of the thickness of coarser roofing slate, while at a distance of less than fifty feet from them, inside the greenstone reef, or trap-dyke, the diggers were bringing up as steadily bucketful after bucketful of the greenish marl. Nor was it from one solitary well-pit that the well-sinkers were bringing up this shale. I crossed the diggings from the first pit I had seen to the opposite side, and there found the well-sinkers bringing up exactly the same black carboniferous shales from 60 to 70 feet.

To all enquiries put to these well-sinkers as to whether they had ever found any diamonds in the shales, the universal answer was the invariable "No;" but I found at the depths where these carboniferous shales commenced in the well-pits, to wit from 5 to 7 feet below the surface, the true marls within the reef also commenced: at exactly the same depths for the first time did the diggers look for any number of diamonds in their claims. So much for the first correspondence traceable between the carboniferous shales of the well-pits outside the trap-reef of the New Rush diggings, and the amorphous mass of diamond-bearing stuff within the reef-coil: but, struck by this first correspondence, I subjected the shale formations to further investigation, to see whether in other correspondences I could trace common origin for the carboniferous shales of the country and the diamond stuffs, and I found as follows:—

1st. That deep as some of these marls reached within the reef, the black shales reached without the reef at least to 70ft., the lowest depth to which the well-diggers could sink, because of the water which generally, about that depth, came in to the pit in force and stopped further sinking.

2nd. That as the shales without the reef commenced to shew in colour and texture at a depth below the surface varying little from 6 to 7ft., so at like depth from the surface, the green marls within the reef began to show in all their distinctiveness from surface deposits.

3rd. I found, upon a close investigation, that taking this black shale and subjecting it to the action of fire it yielded up, after a time, the element of blackness in it—an element undoubtedly of vegetable origin—and showed an ashy residue behind, not by any means, when made into a mortar with water, unlike the marl stuff of the diggings.

I found also, by accident, one other very interesting fact in connection with these shales, or rather with the water drawn from the wells sunk in them. This water a friend found in his bath every morning covered with an oily scum of clearly vegetable origin: and, if the water found rising in wells sunken among the shales could be so impregnated with a species of paraffin, or oily substance so rich in carbon, who will say that in these carboniferous shales of the country, a source of carbon, abundantly sufficient, may not have been found for the origin of all the diamonds now being unearthed at Colesberg Kopje. Beyond this striking feature of the diamond-fields just brought to my notice by the well-sinkers at Colesberg Kopje, I noted one or two other points there, not altogether wanting in interest.

Among these I would repeat to you here the following:—1st. I found wherever the diamond was obtained perfect in form, and smooth to finest smoothness of surface, without depression, hump, or twist of any kind, such diamonds were ever found in their own little moulds of finest limey stuff, as if such mould of lime had been a necessity to its perfect formation. 2nd. And farther I found, that where the splinters of diamonds, or borty stuff, were chiefly met by the diggers, there was much less presence of limey matter in the claim at the section of it where such broken or fragmentary diamonds were found, and that chiefly from among what the diggers termed "clay-ballast" or "burnt brick," were unearthed the bits, or undeveloped crystals, so plentiful at New Rush.

I know not that there was anything further particularly noteworthy at New Rush diggings, the greatest of all diggings yet discovered; —but the river diggings had still to be visited. These are situated on the Vaal, and in its bed, about 20 miles from New Rush; and it was re-

ported to me by many diggers and others from the river, that there the diamonds were found, not in the greenish marl, but in the red soil of the country, among the great trap-boulders of the greenstone dykes. These reports seemed terribly to conflict with the theory of the diamonds which all I had yet seen seemed to force upon me, and I hastened to Pniel, the first of the river diggings, to examine for myself. There I found the diggers certainly sinking through the red soils of the country, and among the trap-boulders of the adjoining greenstone dykes; but not until they had passed through the red ferruginous soil, and reached a bed of the familiar well-known marl, like a great mortar layer in which were bedded round greenstone boulders, did the diggers find any of the sought-for diamonds. And here, indeed, I was struck in watching the operations of some diggers, as I heard them one day shout out as they reached a patch of the marl stuff, "Ah, here is the true stuff at last."

To the question whether, under the present rich findings in South Africa, the fields there may not be soon worked out or exhausted, I think I may give an emphatic negative, and for the reasons I have already advanced, and to be very briefly recapitulated here.

I have told you of the immense area of Diamond-land—over 10,000 square miles, through the whole of which centres of diamond deposit of more or less richness have been discovered. I have detailed to you the richness of some of these centres, as New Rush, from which in six months a million sterling of diamonds under very imperfect search have been extracted. I have named to you the mounds of excavated stuff around New Rush, from which, under second search, I confidently believe as many diamonds as have already been extracted will again be found. I have mentioned to you the depths of these diggings, already in many claims 100 feet and more, and told you that in the revealed sections of the country at the river diggings of Gon Gong and Delport, evidence is given that for 300 feet the diggers may go down in these claims and yet not touch the bottom of the diamond marls. I have called your attention to the frequent occurrence of great diamond centres in the country, when a section of only 8 miles of it, laid open by the river, has revealed the presence of two such centres within that limited space. Finally, I have advanced the suggestion that the matrix soil of the diamonds is none other than the

great carboniferous shales of the country, and as these seem to extend there not only over a wide area but also to a very great depth, the product to my mind of a great growth of weed, and reed, and grass, in the shallow waters of a widely extended lagoon which had once covered diamond land; imagination itself fails almost to conceive the wealth of diamond production from such body or world of shales. Diamond-searching is no passing or fleeting enterprize there, but an abiding, continuing industry, not for years only, but for ages.

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2. On Columnar Basalts.

By John Curry, Esq.

(*Abstract.*)

In the introduction the modern views by which heat is regarded as a vibratory motion were referred to. In accordance with these views cold must be considered as only a lower degree of heat, or a lesser intensity of vibratory motion. Such being the only distinction between heat and cold, it necessarily follows that a diminution of the former is equivalent to an increase of the latter, and *vice versa*.

The process of the formation of columnar mud was briefly described. The analogy between this process and that of the formation of columnar basalt being such that the same diagrams served for illustration in both cases, though in the former case hea penetrates the fine clayey sediments, and produces columns of dried mud; in the latter cold advances into the molten lava, and changes it into solid rock, which frequently has a rude, but sometimes a perfect columnar structure. In reference to the production of such columnar structures the chief and most notable conditions are two diverse temperatures, closely situated at the contact surfaces of dissimilarly constituted bodies. The higher temperature the author designates heat, and the lower one cold. In the above instances the dissimilar bodies in surface contact are, first, the at-

mosphere and the fine clayey sediments; second, the oceanic water and the molten lava. While the solidifying of the lava is being effected, the solid and the molten parts may be considered as distinct bodies. It is at and near the surfaces of contact where the exchanges of heat are most efficient in giving structure to the forming bodies. The actions of heat and of cold having directive influence in the formation of hexagonal columns were shown in the figures of illustration.

During a long continuance of hot, dry weather, the cracking of soils and of fine clayey sedimentary muds into polygonal figures must be familiar to almost everyone. The lengths of the sides of any one of such figures are often variable. Figures having five, six, and seven sides are most prevalent. The hexagonal ones were taken as the most perfect and suitable for illustrating the subject. A little after the commencement of desiccation the dried hexagonal mud figures are thin, and the openings bounding them are narrow and shallow; but as the heat advances downwards the former thicken, and the latter grow wider and deeper. A long duration of extremely hot, dry weather increases the figures so in thickness that they ultimately acquire the columnar character. During the process of formation the heat progresses from the tops of the columns downwards, and carries the water from the centre of each figure, somewhat horizontally, into the lower parts of the openings, whence it rises to be expelled at the general surface. The water thus carried off brings the particles of mud into closer union, and, consequently, augments their cohesive force. The laws of action which regulate the formation of columnar mud are evidently very similar to those which produce the columnar form of wheaten starch.

In dwelling on the formation of columnar basalts, it was supposed that much lava was erupted in the bed of the ocean, where it found a resting place, under such conditions, so as to attain considerable depth and area, with its upper surface in a horizontal position. In this case, the dissimilarly constituted bodies are the oceanic water and the lava; the former is the cold body, and the latter the heated one. Thus, two diverse temperatures are closely situated at the surfaces of contact. The extended level surface of the molten mass is exposed to the cooling influence of the oceanic water. It is chiefly from this surface downward that the solidification of the molten mass must obviously proceed. When solidifica-

tion begins, hexagonal figures may be considered as forming, and as being surrounded by extremely small openings. As the cold continues to proceed downwards, so do these figures of the solidifying lava augment in depth, and assume the columnar character. The openings bounding each figure are, doubtless, the result of contraction of the lava on, and after taking the solid state. The diminution of heat, the expulsion of gaseous matter, and the increased power of cohesion, may be referred to as causes of such contraction. The openings, which might in several instances be merely divisional planes, would serve as channels for carrying off heat and gaseous matter upward into the ocean. Columns, formed under such conditions as those just described, would stand perpendicular ; but others occur which have a horizontal position. To account for these, it was supposed, for example, that a deep narrowish chasm is filled with lava, and that the sides of the chasm must be the chief cooling surfaces, consequently, the cold, advancing from them towards the interior, would solidify the lava in that direction, and form horizontal columns. The author cited an experiment by which drops of hot molten tallow, falling on the surface of water, which is near the freezing point, are quickly arranged into beautiful and often symmetrical figures, by the law of exchanges of heat, some of them resembling flowers with six petals.

In the concluding part of the paper, the large surface contacts of the ocean with the bed on which it rests, and the contact of the atmosphere with the land and water surfaces, were adverted to as areas where the exchange of heat had done, and was now doing much work in producing structures. Jointage, cleavage, and various other rock structures, are ascribed as being mostly due to such work. The structure of ice is a marked example ; it bears a striking analogy to the hexagonal columnar structure of basalts. Ice often breaks up into columns by slow melting. The ice of a lake sometimes shows such a breakage when it melts in the spring.

EXCURSION TO ERITH AND CRAYFORD.

MAY 4TH, 1872.

Director:—J. LOGAN LOBLEY, F.G.S.

(Report by Mr. Lobley.)

On arrival at Erith station the party proceeded to the foot of the fine sections of the Thanet Sands, exposed in the great Erith Ballast Pit. This very extensive excavation has been formed by the removal of the loamy sand which here represents the Thanet Sands, and which is used as ship ballast, and subsequently for iron-casting purposes.

The bottom of the excavation is about two feet above the top of the Chalk, which underlies the whole, and is seen at one or two small wells dug through the two-feet bed and a few feet of the uppermost bed of the Chalk below. Wells of little depth are alone required to furnish water in abundance. The proximity of the Thames, and the slight difference of level between that of the bottom of the Ballast Pit and High Water Mark, give here an unlimited supply of water in the bed of Chalk immediately underlying the Bull Head bed, the whole of the Chalk below being filled to saturation. As may be expected, the water falls and rises in these wells with the ebb and flow of the tide in the adjacent river. The sides of the excavation reach a height of sixty or seventy feet, and are formed almost exclusively of the Thanet Sands, the only exception being a small capping of the Woolwich and Reading Series at one place, that, as is to be expected, at which the side of the pit is highest.

When all had assembled at an advantageous spot, a general description of the Thanet Sands formation, its stratigraphical position, extension, and local peculiarities was given, followed by a description of the section then before the Members. A diagram showing the relative thickness and position of the geological formations, drawn to the scale of an inch to the 100 feet, was exhibited, and thus the Members were enabled to appreciate the great thickness of the stratified rocks, since towering high above them they saw a nearly maximum exposure of a formation represented on the diagram by a very narrow band of colour.

The Thanet Sands of Mr. Prestwich, or the Thanet Beds, as Mr.

Whitaker prefers to call these deposits, form the lowest member of the British Tertiaries, and repose upon the Chalk, the surface of which is irregular from erosion. The formation extends from Belgium on the east to Ealing, Middlesex, on the west, underlying the whole of London. They thin out to the west, and were evidently deposited at the bottom of a small sea or bay.

Mr. Prestwich considers that this sea had an exposure to the N.E., and was cut off from southern influences by land. That the Thanet Sands were not deposited soon after the completion of the Chalk deposit is shown by the great fact that the faunas of the Cretaceous and Eocene formations are essentially different, and that only one doubtful species appears to be common to both. Indeed, it is probable that a very great period of time elapsed after the formation of the Chalk and before that of the Thanet Sands; and the Maestrict Beds, the Faxoe Limestone, the French Pisolitic Limestone, the Landenian, and other deposits, remain to indicate to us how much may have been formed during that period.

In the British Area, however, we do not find any of the missing links, but see the Chalk immediately covered by the Thanet Sands, with, however, a basement bed of undoubted significance. This remarkable bed is very thin, and consists of brown clayey matter, resting on, as well as embedding, unrolled Chalk flints, having an external colour of dark bottle green. These green coated flints are locally called Bull Head flints, and are everywhere found at the base of the Thanet Sands. They are evidently derived from the Chalk, which has doubtless been dissolved away by the action of carbonated water from the sands above. The bed of flints, therefore, tells us that the present surface of the Chalk is not the original one.

The Thanet Sands vary greatly, not only in thickness but in lithological and palæontological character. They are, perhaps, best seen in the neighbourhood of Canterbury, where five distinct divisions or beds have been enumerated. Mr. Whitaker has attentively studied these divisions, and has carefully described them in a paper "On the Lower London Tertiaries of Kent," published in the "Quart. Journ. Geol. Soc.," vol. xxii., p. 404, and in a diagram attached to the paper he has very clearly shown the extension and local increase and decrease of each. The following section is compiled from Mr. Whitaker's record of his observations.

SECTION OF THANET SANDS.

e. 30 feet.	Fine Sharp Sand. (Silicified Fossils.)	Reculvers and Pegwell Bay.
d. 93 feet in Belgium.	Sandy Marl. (Fossiliferous. *Cyprina Morrisii, Pholadomya cuneata*, &c.)	Near Canterbury.
c. 60 feet.	Fine Soft Pale Buff Sand. (No Fossils except cast of *Pholadomya.*)	Begins E. of Canterbury, dies out W. of London.
b.	Brown Clay and Loam.	E. of Faversham, Pegwell Bay. (Local).
a. 2 to 5 feet.	Clayey Bed with green-coated Flints.	Persistent everywhere.

After leaving the Ballast Pit, the party ascended the hill on the south, and inspected exposures of the Woolwich and Reading Series and of the Oldhaven Beds, which latter consist in this place of a great accumulation of rolled pebbles, though at the typical locality (Oldhaven Gap) they are sands and clays.*

The extensive excavation known as White's Pit was next visited. At this place a most interesting section of the Old River bank is seen covered by a great deposit of Pleistocene sands and brick-earth. The Thanet Sands, which, at the Ballast Pit, about half a mile distant, are sixty feet thick, are here only fifteen feet in thickness; they rest on the Chalk, and form the summit of what was a steep river bank. The Pleistocene deposits yield *Cyrena* (*Corbicula*) *fluminalis, Valvata piscinalis, Pisidium amnicum, Bythinia tentaculata*, &c., and from them have also been derived remains of several species of Mammalia, including, according to Mr. Boyd Dawkins, *Bos primigenius, Canis lupus, Elephas antiquus, E. primigenius, Equus fossilis*, and *Felis spelæa.*

The interesting character of the sections at this place, and the abundance of the fossils, invited a longer examination than could be given, for the still more interesting and important, though in all essential respects similar, excavations near Crayford had yet to be

* See Proc. Geol. Assoc. vol. ii., p. 38.

visited. Leaving White's Pit with evident reluctance, the Members gained the pleasant Dartford Road, and skirting the broad, alluvial flats which once formed part of the bed of the spreading Thames of old, but now the valley of the narrow Cray, the great excavation at Crayford was soon reached.

The sections exposed here are very varied, and display some remarkable features of the ancient Chalk river-banks, which have been preserved from destruction or even injury by the enveloping Pleistocene deposits. One of the most noteworthy features of these old river-banks is a beak of Chalk, projecting sufficiently to cover a mass of Thanet sand, which, after removal from its parent bed, was deposited underneath the beak, and was thus protected from disintegration. The fauna is, as might be expected, similar to that of the Erith Pit, but the remains of Mammalia found at Crayford give us a list of species much longer than the list of those from Erith, which includes but six species, while sixteen have been recorded by Mr. Boyd Dawkins as having been found at Crayford (See Proc. Geol. Assoc., vol. ii., p. 230). A tunnel connects the great Crayford Pit with a chalk pit, in the walls of which latter excavation may be seen several of those curious and obscure cavities known by the name of "Grimes's Graves," and ascribed by some to the search for flints by the pre-historic inhabitants of the district. After some time was spent in the observation of various portions of the two pits, the party returned to Erith, and subsequently to London.

VISIT TO THE BRITISH MUSEUM.

SATURDAY, MAY 11TH, 1872.

Directors:—PROFESSOR OWEN, F.R.S., and HENRY WOODWARD, ESQ., F.G.S.

This meeting was rendered interesting by a very valuable lecture which Professor Owen delivered to the Members on their assembling in the hall devoted to the display of the national collection of the fossil remains of the Mammalia. Commencing with a description of the Australian *Diprotodon*, represented by the kangaroo of the present time, the learned Professor drew attention to the marsupialian character of the fauna of the great Australian Continent, which seemed to indicate that life had made less advance in that portion of the world than in others. Amongst other characters which were empirical, the peculiarities of the canal in the

lachrymal bone were mentioned. A very small brain characterised the Marsupialia, which curious order of the Mammalia included carnivorous as well as herbivorous species, in the latter of which attention was called to the procumbent position of the lower incisors.

The teeth of the *Mastodon* were then briefly described, and specimens of the young of the North American species were pointed out showing small tusks in the lower jaw as well as the upper. The former were shed in the female when the animal attained a greater age, but one lower tusk was retained in the male. After some observation on the *Deinotherium*, in which the lower tusks only are developed, which is of Middle Tertiary Age, and has a geographica extension through Germany and France, with indications of its existence in the Red Crag of Suffolk, attention was directed to the genus *Elephas*.

A pair of enormous tusks in the centre of the room are the largest fossil tusks known, and were obtained at 1,000 feet above the level of the sea, in Northern India, by Sir Proby Cautly, in company with the late Dr. Falconer, and an interesting account of the discovery of the tusks and their extraction from the rock was given by Professor Owen. The species has been named *Elephas ganesa.*

Though the tusks of the Elephants are of homogeneous structure, and composed of ivory throughout, the molar teeth of these pachyderms are composed of plates of various density which, with wear, produce a serrated surface most useful to the animal for mastication. In the centre of each ridge there is a plate of dentine, at each side of which is a plate of very hard enamel, and outside of the plates of enamel, which are the hardest plates, there are plates of *cementine*, the softest material of the three of which the tooth is composed. The *Elephas primigenius*, or Mammoth, found so abundantly at Ilford, and at other localities in the Thames Valley, and of which an entire specimen was found frozen on the banks of the river Lena, in Siberia, is characterised by having a greater number of dental plates than any other species.

Passing to the South American fossil Mammalia, the *Megatherium* formed the subject of an interesting demonstration, in which the habits of the animal when alive were clearly shown to be indicated by the skeleton. It is very evident that the *Megatherium* was a gigantic sloth, and a fractured skull of a Megatherium in the Museum of the College of Surgeons showed that the animal when alive climbed trees and sometimes fell to the

ground. The structure of the skeleton, however, shows that the animal possessed enormous power for the overthrow of trees, which was doubtless often availed of when the leaves were otherwise unprocurable.

In both the sloth and the *Megatherium* the hind feet have three toes each, but in the *Megatherium* only one of the toes is armed with a claw, while each one in the foot of the sloth is furnished with such an appendage. The single great claw was doubtless used for the bareing of the roots of trees, while the great pelvis, the large and massive hind legs, and the enormously strong tail, enabled the Deinotherium to erect himself on a most firm tripod, and shake the tree with the breast and fore legs until it fell. The anterior extremities of quadrupeds usually move in one plane, but the fore legs of the *Megatherium* are so articulated that they can be moved in a manner similar to the movement of the human hand. This would materially aid in the grasping and shaking of trees, and the very large *clavicle* would also contribute power. The tongue bones indicate a large and powerful tongue, supplied with a great amount of nervous matter. It was long, cylindrical and prehensile, and passed along a large and symmetrical channel of the lower jaw, beautifully shown in the Museum specimen.

What the *Diprotodon* is to the kangaroo, the *Megatherium* is to the sloth of South America, and as the Marsupialia characterises Australia, so are the Endentata the peculiar fauna of South America. Thus we see, as was shown by Professor Morris in his lecture on the occasion of the visit to the Museum in 1871, that in the latest geological deposits the orders, if not the genera, are the same as those now inhabiting the same zoological provinces of the globe.

Attention was directed to the fine collection of fossil teeth, and to a specimen of the hair of the *Elephas primigenius* from the Siberian mammoth.

Professor Owen concluded his lecture by some remarks on the geological age of the *Megaceros Hibernicus*, or Irish Elk, which is commonly supposed to be found in the bogs of Ireland. This is not strictly correct, as all the specimens have been derived from the shell-marl which underlies the bogs. This is so also in the Isle of Man and in Lancashire.

The President tendered to Professor Owen the cordial thanks of the Members present for the very instructive and valuable lecture, to which they had listened with great pleasure.

At the conclusion of Professor Owen's lecture Mr. Henry Woodward described to the Members a portion of the fossil Invertebrata contained in this portion of the Museum, especially noticing the Echinodermata.

After a vote of thanks to Mr. Woodward, the proceedings terminated.

EXCURSION TO BATH.

MAY 20th and 21st, 1872.

Directors—CHARLES MOORE, Esq., F.G.S., Hon. Memb. Geol. Assoc., and the Rev. H. H. WINWOOD, M.A., F.G.S.

(Report by the Rev. Mr. Winwood.)

The Members were received at the Bath Literary and Scientific Institution, and were conducted through the Museum containing the valuable and interesting Palæontological Collection, which is almost solely the result of one long life of patient research—the noble contribution of Mr. Charles Moore to Geological Science.

It was with great interest that the visitors listened to Mr. Moore's descriptive lecture on the Collection, which is stratigraphically arranged and beautifully displayed in a large series of cases occupying the entire area of the principal room of the Museum. Commencing with the Post-Pliocene remains, specimens of *Ovibos* and *Elephas* from Avon Valley deposits were shown, then a fine series of fossils from the Chloritic Marl of Somersetshire, and afterwards a large number of organisms from Purbeck beds, considered new to science. As the visit was chiefly to inspect those Lower Oolite and Lias fossils which have made the Bath Museum famous, the Upper and Middle Oolite cases were rapidly passed.

The fauna of the Great Oolite in the immediate neighbourhood of Bath is but meagre when compared with that of Minchinhampton sections; nevertheless the Corals of the "raggy beds" of Hampton Down are remarkable. A very fine and interesting series of *Ichthyosaurus*, *Teleosaurus*, fish, crustaceans, insects, &c., occupying case after case from the Upper Lias were then described, and the nodules containing fishes were shown to possess forms corresponding with those of the fossils within. After the testacea from the Upper and Middle Lias were inspected the attention of the party was directed to a series of diagrams

shown on the walls of the Museum, and giving typical sections of the Lower Lias. These sections Mr. Moore contrasted with abnormal ones in widely separated localities.

From their number, size, and completeness, the Lower Lias Saurians form a conspicuous feature of the Museum, but the fossils which attracted most attention, and excited greatest interest, were the remains of those earliest British Mammals, *Microlestes antiquus* and *Moorei* from Rhætic deposits, of which Mr. Moore was the discoverer, and that wonderful collection of seventy thousand *Acrodus* teeth from the same Rhætic Series obtained by Mr. Moore from three cart loads of material taken from a fissure in Carboniferous Limestone near Frome.

A beautiful collection of Secondary Brachiopoda with many new forms, shortly to be described by Mr. Davidson, having been inspected, the thanks of the Members were cordially given to Mr. Moore, who, although in very feeble health, had so kindly exerted himself on behalf of the Association.

The party now proceeded, under the guidance of the Rev. Mr. Winwood, to visit some of the sections in the immediate neighbourhood. The first halt took place at the Newbridge Hill cutting, on the Bath and Mangotsfield Railway, permission having been kindly granted by the authorities for this special visit. Mr. Winwood, who has read a paper before the Bath Field Club on this section, gave a short sketch of the boundaries of the Bristol and Somersetshire coal basin, at the eastern edge of which the Members were then standing, made a passing allusion to the remarkable thinning out of the Secondary beds to the north of the Mendip range, evidence of which he hoped to show the Members in their morrow's walk, and then gave a general idea of the section before them. Extending in a N.W. and S.E. direction the Members saw exposed a series of beds from a thin representative of the bone bed, a little below the present rails, through the superincumbent blue shales, with intervening hard, light blue, or gray marly bands onwards through the Cotham Marble or Landscape-stone at the base of the White Lias, and upwards through this latter formation and thin representatives of *Ostrea* and *Ammonites angulatus* beds to the dark blue clays of the *Lima*, or *A. Bucklandi* series of the Lower Lias.

All the beds from the new red marl faulted up at the farthest end of the cutting, upwards to the topmost bed of the White

Lias, called the "Sun bed," by William Smith, were now considered to be the English representatives of the Rhætic beds on the Continent. Though the bone beds and *Avicula contorta* shales were much better represented in the Garden Cliff and Aust sections, yet, probably, nowhere else was the White Lias so admirably exposed, graduating from the rubbly and fossiliferous beds above the "Landscape-stone," up to the thick and compact "Sun bed," so persistent in the Somersetshire sections. Attention was called to the pretty series of step-like faults which finally caused the White Lias to dip rapidly beneath the railway, and disappear altogether at the S.E. end of the cutting. After these preliminary remarks the Members made a closer inspection, and notwithstanding a heavy shower which somewhat interfered with the work of the hammer, were enabled to satisfy themselves of the position of the bone bed with its characteristic *Pecten Valoniensis*, and that the true Rhætic fossils were present. Specimens of the "Sun bed" were carried away for analysis, and the distinct lithological change between this bed and the thin yellowish brown arenaceous band, containing *Ostrea liassica* which persistently overlies it, was an evident and marked feature.

The Association were fortunate in having with them Dr. Wright, of Cheltenham, who contributed information respecting the general question of the position of the Rhætic Series. Time being on the wing and the shower over, the party made for the Twerton quarries, passing on their way a small exposure of mammalian drift, consisting principally of pebbles from the rocks of the neighbourhood, Oolite, Lias, Mountain Limestone, flint chert, &c. Arrived at the quarries, where a fine exposure of the Lima-beds of the Lower Lias were seen, those unacquainted with the district were surprised to find a coal shaft sunk through, and coal won at a depth of 118 fathoms beneath, the Lias. Several characteristic fossils were obtained, and the Members returned to Bath.

On the following day an early start was made, and the Great Oolite quarries on Hampton Down were first visited. A few words on the workable "freestone" beds which intervene between the Upper and Lower "Rags," and are here about 25ft. in thickness, and the Members passed along the edge of the Down overhanging the beautiful Valley of Warley, with the river, road, rail, and canal forming pretty peeps in the bright sunlight, and reached a picturesque and fern-clad hollow, formed by the falling in of the roof of the

numerous galleries which run into the hill. Here Mr. Winwood pointed out the brown raggy coralline bed, about 9ft. thick, whence Mr. Moore had obtained so many of the sponges, bryozoa, and corals, now in his collection, and several specimens were collected from the weathered edges, together with *Terebratula cardium*, &c.

A pretty walk across Claverton Down took the party to the Dundas Aqueduct. Geologists being essentially material, refreshments at the Aqueduct Inn were much needed, and obtained before the hammers were again set to work. The Members were brought here to see an illustration of the thinning out of the Secondary beds previously alluded to. They saw before them one of the few sections where the Upper Lias had been found in this neighbourhood. They were then standing (according to the section given by Mr. Moore) on blue micaceous marl, 20ft. in thickness. Just above this came a band of Marlstone, 1ft. thick; blue clay, 3ft.; Upper Lias, one bed, 1ft. thick; grey clay, 2ft., succeeded by the sands of the Inferior Oolite, 20ft.; thus the Middle and Upper Lias, which are of great thickness in the North of England, are here reduced to 7ft. *Ammonites Walcotii* and *A. serpentinus* (?) were obtained from some of the blocks lying about, and one or two *Lingula Beanii* from the brownish Marlstone. It must be confessed, however, that owing to the section being so covered with luxuriant growth a good deal was left to the imagination to fill up, aided by the statements of those who have worked it out before. A traverse through a keeper-guarded wood, and along the canal bank, crowded with recent Mollusca, the result of bottom dredgings for mud, and the last section was reached—the section whence Lonsdale obtained many of his Inferior Oolite fossils. A small exposure of the sands was seen at one end rising immediately from the banks of the canal, the bed of which is in Lias clay, and succeeding these sands came the Inferior Oolite, with the Fuller's Earth clays on top, but not visible; thus in a section of about 25ft. in thickness the beds of the Cotteswolds, reaching a thickness of 170ft., were represented. Several fossiliferous bands were seen in the beds. Time did not permit of a visit to the Freshford gravels, whence the head of *Ovibos moschatus* was obtained, and accordingly the Members returned to Limply Stoke, and took the train to Bath, having been highly gratified with the result of the day's excursion.

EXCURSION TO GUILDFORD AND CHILWORTH.

JUNE 1ST, 1872.

Directors:—Professor T. RUPERT JONES, F.R.S., F.G.S., Hon. Memb. Geol. Assoc., &c., and C. J. A. MEÿER, Esq., F.G.S.

(Report by Professor T. Rupert Jones.)

The Members, headed by Mr. Meÿer and the Secretary, met Professor Rupert Jones and friends from the Royal Military College, Sandhurst, at the Guildford Railway Station, and at once proceeded to examine the section of the Woolwich and Reading Beds just north of the station. This section was described by Mr. Prestwich in 1850 (see Quart. Journ. Geol. Soc., vol. vi., p. 260, fig. 6), not long after it had been exposed by the railway-cutting. A year ago it was laid bare afresh when widening the railroad, but already the slipping of the clays has obliterated some points of interest. Traces of the shell-beds, with *Cyrena* and *Ostrea*, below the representatives of the "Oldhaven Beds," are to be found at the base of the telegraph post, 100 yards south of the road-bridge, and the underlying mottled clays, with a dip of 4° to the north, are easily recognized for about 190 yards to the south, where a small valley (about 50 yards across) has been formed by denudation out of the sands and lowest green sandy clays resting on the Chalk, which forms the northern foot of the Hog's Back or Surrey range. Here the Chalk is seen to be traversed in every direction with fissures, often slickensided; some empty, some filled with vein-flint, and some with loamy stuff. Nodules, and occasional thin laminæ of flint, follow the dip of about 6° to the north, and many are in a crushed condition. Bands of marly Chalk also lie on the same plane. Some Echinoderms were met with.

Mr. Godwin-Austen, F.R.S., of Chilworth, now joined the party, who next visited the much larger excavation of the Chalk at the entrance of the railway tunnel. Here the dip, well marked by flints and marly bands, is about 12° to the north. Fossil sponges, echinoderms, *Inocerami*, &c., abound in this pit. The usual chalcedonic and quartzy interiors of hollow flints attracted notice, and Professor Rupert Jones drew attention to facts that seemed to him to bear evidence of flint being a pseudomorph after Chalk. Leaving this instructive section, and following the pretty suburban road out of Guildford towards Godalming for nearly a mile, the

party turned off to the right along a country road parallel with the Chalk-range, but separated from it by the deep valley cut along the strike of the soft Gault. This led them to a quarry in the Lower Greensand on the escarpment overlooking the pathway to Losley. In this section of those Neocomian beds known as the Bargate-stone, the waterworn sand of quartz, ironstone, lydite, and hard green silicates is so largely mixed with calcareous fragments (the *débris* of shell-beds, polyzoan reefs, &c.), that it is here and there cemented together hard and compact enough to serve as a building-stone and for road-metal. Mr. Meÿer, working here as a geologist for years from time to time, has made this quarry "classic ground" for his scientific brethren, as his publications prove, and on this occasion he kindly pointed out the several species of *Terebratula Avicula, Polyzoa*, and other fossils that are peculiar to this formation, or that link it with that at Upware and other places. Especially he directed attention to the horizon at which he obtained an unrolled tooth of *Iguanodon*, indicating the existence of this great Dinosaur at perhaps the latest period to which any of its remains are as yet known to belong. The "false-bedding" of the sands, due to the southward set of prevalent tides and currents, and the probable origin of their materials from the "old palæozoic ridge or shoal," as taught by Mr. Godwin-Austen, who first made out its existence and history, and who knows every stratum of the country, were also studied. The formation of the escarpment, with the correlative parallel cracks and fissures of the strata, was also noticed by Mr. Meÿer and his interested followers. Leaving the fascinating lessons of the quarry, and the beautiful woodland views of the neighbourhood, the geologists retraced a portion of the pleasant route until they crossed the Portsmouth-road at the foot of St. Catherine's Hill, and then went down to the ferry, where St. Catherine's Spring issues beneath the hill from a little cave in the red orange-tinted sand, draped with deep green mosses. The ferryboat placed them in view of the suddenly picturesque cliff of rich-tinted sand, bearing St. Catherine's ruined shrine a-top, on the right hand, whilst the flat alluvial valley of the Wey, grassy and wooded, led away towards the white cliffs of quarried chalk opposite, and the tapering church spire of Shalford, the river windings, the villas, old Guildford Castle, and other signs of the past and present, suggested thoughts of mingled hue.

Nor did the geologist forget to dive below the surface and tell

how, for 30 feet at least, the Guildford gap has been found by boring to be occupied by bouldered chalk, and other detritus, due to the destructive and yet conservative agencies of nature. Threading the grassy paths of Shalford Park, the tourists came to the turnpike-road, and entered a lane on the soft irony beds of the Lower Greensand, and followed their strike along the woods, with the red-yellow sands of the hill on the right, and the Gault valley on the left, for about a mile, until a short field-lane, crossing the Gault and Upper Greensand, led into the Chalk-marl quarry below Warren Farm. There, as Mr. Meÿer explained, the loss of the clay-beds (Gault) from below by their having been squeezed out along the southern side, had allowed the hard marl-rock to subside inwards, suddenly, at the escarpment, and to rest at a high angle (70° and more), whilst the Chalk of the hill-range above dips only five or six degrees. As the hard rock-bands here quarried for lime are followed end-on along the "strike" open to day, the backs of lower beds form one side of this deep, narrow pit; and the truncated edges of these somewhat bent and much fissured strata warn the instructed eye of the danger of standing either below them or above them, lest either rain or drought should detach their clinging surfaces on the sloping bed plane. The down-turned edges of the strata, under the sward of the hill-side, are also observable, having been bent over and downwards by the combined action of rain, frost, and snow, on the slope of the hill. Large ammonites and nautili are the chief fossils met with here; but *Pecten Beaveri* and *Terebratula* are also found. In an old excavation in the lane *Siphonia* has been found in the representative of the Upper Greensand, which is overlain by dark green sandy clay and Gault, turned up at a high angle (and probably squeezed out) in the breadth of a few yards, before the iron-sands are reached on returning to the hill-side.

Once more continuing the walk along the woods, and crossing the picturesque transverse slopes and gullies leading down into the fertile Gault valley on the left, the party came to the foot of St. Martha's-hill, or St. Martyr's-hill, for martyrs (Mr. Godwin-Austen told us) were burnt on the hill by the pagan Saxons; and St. Martha was one of these Romano-British sufferers. Before mounting this broomy hill of sand, seamed irregularly with ironstone, some of the party descended the Halfpenny-Hatch Lane leading down towards the East Shalford bottom, and saw a section

of sands and calcareous sandstones with fuller's-earth bands and pebbly beds, similar to that in the quarry on the other (western) side of Guildford.

On the hill-top is St. Martha's Church, enshrining (it is said) the spot of martyrdom, and involving some of the structure of the Roman watch-tower. But undisturbed by melancholy thoughts of the past, nor looking out for mortal foes coming from the south, whether bearing Saxon spear, Norman cross-bow, or Prussian needle-gun, the geologists, blest with fine weather, delighted in the wide stretch of "London Tertiaries" on the north, and the broad expanse of Wealden on the south, and thought of far older inhabitants than even Celt or Teuton, of whatever race, and of greater physical changes than ever Roman or Norman brought about. On this elevated ground, and amidst the rustic graves which surround the ancient shrine, Professor Rupert Jones spread his diagrams and maps of Jurassic and Cretaceous seas and lands, whilst Mr. Godwin-Austen, at home in his own well-wrought geological field of research, and in courteous compliance with the assembly's request, told how the underground structure of south-eastern England is connected with that of the Boulonnais, Belgium, the Ardennes, and Westphalia; and how the folds and ridges of palæozoic rocks which, in those countries, bear up, either at the surface, or just beneath the Chalk or the attenuated Oolites, valuable coal-beds, are continued through, in a broad sweeping line, underneath parts of Surrey, Kent, and Sussex, until visible again near Frome, in the Bristol coal-area, in North Devonshire, South Wales, and the South of Ireland. The old faults and fissures affecting this linear tract of old strata had long before the Coal-period raised and depressed the lands and sea-beds; and as a great spur of the old Scandinavian lands, this tract afforded ground for the littoral growth of the jungles that formed the coal on its oscillating borders, and in its lagoons, now shut up by bars, and now losing their marsh features by influx of the sea. Succeeding ages still brought oscillations and changes, until the Jurassic seas crept over this old ridge or shoal, and the Cretaceous seas quite buried it, at first in sands and clays, and ultimately by the calcareous ooze of oceanic depths.

But again another contracting crush of the earth's crust operated on the old weak lines, and the buried ridge slowly uprose, and its coatings of thick strata were worn off by sea and rain, making

pebbles and sands for the Lower Tertiaries; and, still rising, it was at length laid bare in the Franco-Belgian and the Bristol areas, whilst our Wealden valley of elevation, and those of Kingsclere, Shalbourn, and Pewsey, show where its uneven back approaches near the soil.

Mr. Godwin-Austen fully explained the views and operations of the subscribers to the "Sub-Wealden Exploration Fund," mainly planned and conducted by Mr. Henry Willett, of Brighton, actuated by his enthusiastic love of science, and by an honourable wish to invest Brighton with the credit of good work and scientific enterprise on the occasion of the British Association Meeting.

The basis of the research rests on the following data:—

"1. That, if the Oolite exists, it is probably not of greater thickness than 700 feet, as in the Boulonnais district, in France.

"2. The Oolite may possibly, but not probably, be absent altogether, as in Belgium.

"3. The Mountain-limestones have been reached near the surface at Hécourt, in a district physically a counterpart of the Wealden Formation.

"4. The boring should be made in the Lower Ashburnham Beds.

"5. To use Mr. Austen's own words:—

"'A boring to the base of the Wealden Series, and through the Secondary strata which underlie, cannot fail to have its practical application in the knowledge of the direction in which the true Coal-measures may be met with.'

"6. The uncertainty takes the problem out of the sphere of an experiment likely to prove remunerative in a commercial sense, while it adds to its interest as a question of pure science."

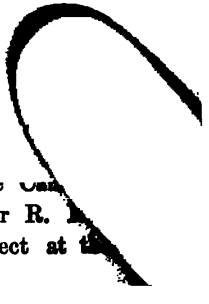
The place for the experimental boring is near Brightling, in Sussex, not far from Robertsbridge, where the lowest known beds of the district come up to or near the surface. It is to be distinctly borne in mind that the exploration has been commenced, not so much to seek for coal commercially as to prove the order of strata, and to learn what is the real structure of this part of England. Even if the Carboniferous strata be met with, they may be unproductive of coal; and they are certainly as much crumpled and distorted as those of Belgium and Westphalia, and thus greatly deteriorated at whatever depth they may be found. (See the Report of the Royal Commission on the Coal-supply of Great Britain.)

After Mr. Godwin-Austen's lecture, and turning from the fine series of maps and diagrams around which they had been gathered, the geologists stood at the edge of the small plateau, and looking southward over the great Wealden area, listened to Professor Rupert Jones while he explained the beautiful and complex valley of the Weald, and pointed out the many Lower-Greensand hills and knolls which fringe the northern edge of the valley, and give to this tract of country its far-famed picturesque beauty.

Professor Rupert Jones clearly showed that the hills and vales coincide with the harder and softer strata "brought up," to use his own words, "by grand but gentle curves, in orderly arrangement, round a long elliptic dome, reaching from Alton on the west to Hastings and, beyond the Straits, to France, and worn down by natural agencies, of long continuance, from a high broad ridge to the present comparatively low series of lesser ridges, and drained by rivers, following the radiating cracks of the raised ellipse, which have still kept their outward course through sandrock and chalk downs, deepening the widened rifts, until the Pluvial Period was overpassed, and now meander slowly among the gravel beds and alluvial flats, till they reach the Thames on one side, and the Channel on the other."

Descending by a charming walk through the woods on the steep hill-side, the party entered the grounds of Mr. Godwin-Austen and re-assembled at his residence, Chilworth Manor, an ancient hall, beautifully situated on the southern slope of the hill, where welcome rest, pleasant discourse, an elegant repast, and the courteous hospitality of Mr. and Mrs. Godwin-Austen crowned the fine day's work. At the conclusion of the dinner, Mr. Lobley, the Secretary, took occasion to offer the thanks of the Association to their entertainers, and congratulated the Members present on the interesting and successful character of the day's proceedings, which had afforded them an opportunity of learning, under most favourable conditions, the views of two such eminent authorities as Mr. Godwin-Austen and Professor Rupert Jones on one of the most important geological questions of our time.

After some time spent in inspecting a collection of fossils, and enjoying the antique gardens around the fine old mansion, the Members were escorted through pleasant lanes to the Chilworth Station on their return to London.



Communication: the classifications, therefore, of the Cam
and Silurian Rocks, by Professor Sedgwick and Sir R. I
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ORDINARY MEETING, JUNE 7TH, 1872.

Rev. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

he following Donations were announced:—

Memoirs of the Geological Survey of England and Wales," iv., "The Geology of the London Basin," by William Whitaer, B.A., F.G.S., from the Author.

Thesaurus Siluricus, the Flora and Fauna of the Silurian iod," by J. J. Bigsby, M.D., F.G.S., from the Author.

Sketch of the Geology of the Neighbourhood of Banbury," Thomas Beesly, F.C.S., from the Author.

Report for 1870 of the Geological Survey of Ohio," from the o State Survey.

Thirty-ninth Annual Report of the Royal Cornwall ytechnic Society, 1871," from that Society.

Quarterly Journal of the Geological Society," from that iety.

Abstract of the Proceedings of the Geological Society," from Society.

Proceedings of the South Wales Institute of Engineers," n that Institute.

he following were elected Members of the Association :—

eorge Blumberg, Esq.; James Campbell, Esq.; William pple, Esq.; Edwin Litchfield, Esq.; Samuel Rowles Pattison, ., F.G.S.; Mrs. Robins; Miss Jane C. Seel; W. T. Stone, .; Thomas Warburton, Esq.; and Cecil Ray, Esq.

he following Papers were read :—

ON THE CLASSIFICATION OF THE CAMBRIAN AND SILURIAN ROCKS.

By HENRY HICKS, Esq., M.R.C.S., F.G.S.

eological science is so progressive, and new discoveries are so quently made, that it can scarcely be expected that the classifi-on of any portion of the series of stratified rocks can re-in long without the necessity for considerable change and dification: the classifications, therefore, of the Cambrian Silurian Rocks, by Professor Sedgwick and Sir R. Murson, made many years ago, and sufficiently correct at that

time, are now in several respects unsatisfactory. Even at present, when so much still lies hidden from our view in unexplored regions, any attempt at a classification must be more or less imperfect, though it is satisfactory to find that fresh discoveries leading towards a natural arrangement are continually being made.

Systems of classification are necessary, if only for working purposes, and doubtless cannot be dispensed with on that account; still, it must not be forgotten that all lines of division, wherever placed, are more or less arbitrary, for we have only one great natural system to deal with, and, therefore, as Nature from time to time unfolds herself to us, so these lines have to yield and give way to others.

We know also that there are numerous breaks in the succession even at present, and we avail ourselves of these accidental circumstances frequently for purposes of classification; but as these have arisen chiefly from faults in the strata, denudation, and such causes, we must expect to be able to fill up many of these gaps as our knowledge of hitherto unexplored and imperfectly explored regions becomes more satisfactory.

It is important also to bear this fact in mind in examining the organic remains of succeeding groups; for, however dissimilar the forms in these groups may appear, this must not be looked upon as a want of accord in nature, but as evidence only of the absence, by some accidental cause, of deposits, which, had they been present, would have shown how unvaryingly true Nature has always been to her laws.

In the accompanying Table the groups of strata which are known, collectively, to form at present the Lower Palæozoic rocks of this country are placed in their natural order of succession; and side by side the classifications of these groups, as adopted by Professor Sedgwick, and by Sir R. Murchison, along with the one now proposed.

All rocks not newer than the Bala Limestone were placed by Professor Sedgwick in his *Cambrian*, which was divided by him into an *Upper*, *Middle*, and *Lower* portion; the *Upper* consisting of the Bala group, and the Arenig or Skiddaw group; the *Middle*, of the Tremadoc, and Ffestiniog groups; and the *Lower*, of the Harlech, and Longmynd or Bangor groups. His *Silurian* included the beds from the base of the May Hill group to the top of the Downton Sandstone, the Bone Bed, and Upper Ludlow.

By Sir R. Murchison, the *Cambrian* was made to include only

the beds contained in Professor Sedgwick's *Lower Cambrian*, viz., the Longmynd or Bangor group, and the Harlech group, the whole series above these being called *Silurian*, or rather, in his most recent work, *Primordial Silurian* and *Silurian*, the name *Primordial Silurian* being adopted by him after the publication of the researches by Mr. Salter and myself in the Menevian group in Wales.

Murchison's classification varied considerably from time to time (the last being that published in "Siluria," in 1868, and which corresponds with the one in the Table), and apparently not so much with a view to a more natural arrangement as to include all fossiliferous rocks of the early formations in his Silurian, leaving the term Cambrian only to what he in 1868 called the sterile bases of the fossiliferous rocks; these "sterile bases," however, even in that year proved to be themselves richly fossiliferous.

The divisions now proposed differ in several particulars from those of Professor Sedgwick, and Sir R. Murchison, and are an attempt at a more natural arrangement in accordance with Palæontological evidence. This arrangement has already been adopted to a great extent by Sir Charles Lyell, in his "Student's Manual of Geology," 1871, and by Mr. Salter and myself in several papers.

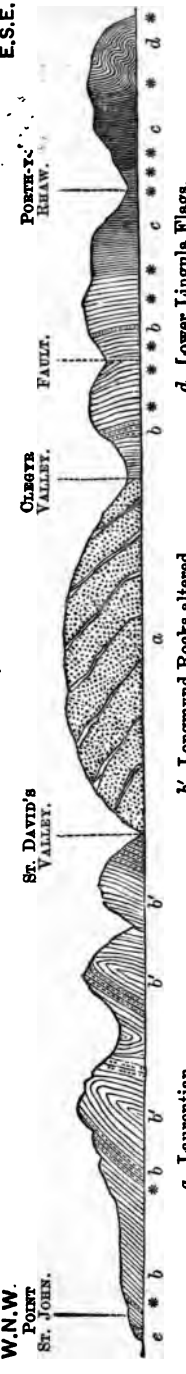
I have left out from the Table the rocks which of late years have become known to us under the names *pre*-Cambrian or Laurentian, as they have yielded no organic remains at present in this country. Moreover, their position is easily recognised, and no difficulty is likely to occur with them. They appear generally as quartziferous or granitic rocks, with a strike from N.W. to S.E., and, hence, discordant to that of the overlying Cambrian strata, which invariably in this country has a strike from about N.E. to S.W. These *pre*-Cambrian rocks occur as ridges in the strata in the neighbourhoods of St. David's, and Malvern, Charnwood Forest, the Hebrides, and western parts of Scotland.

In the Table the lowest group is the Longmynd, so named from the Longmynd hills of Shropshire. This group is usually divided into an upper and a lower portion, the former supposed to be equivalent to the Harlech Grits, and the latter to the Llanberis Slates. There is no evidence, however, at present to show that the Llanberis Slates are older than the Harlech Grits, for the difference in their lithological characters may easily

be explained, as stated by Sir C. Lyell, by looking upon them as deposits of fine mud thrown down in the same sea, on the borders of which the sands of the Harlech Grits were accumulating. The great thickness of the strata in the Longmynd hills has naturally led authors to believe in the probability of a more ancient series occurring there than is present in the Harlech district, but this view seems not borne out by actual facts, since there is every probability of repetitions of the strata in the Longmynd district, as is the case at St. David's; moreover, after an examination of the beds at these places, I am inclined to believe that in no case does the actual thickness of the series, without repetitions, attain to nearly what has been usually given to it in the Longmynd hills. The series so well exposed in coast sections at St. David's is evidently identical with that in North Wales, and Shropshire; the lithological characters and the order of succession being strangely alike, and even the thickness, when any particular series is exposed to view, shows only a very slight difference. The lowest beds at St. David's, in my opinion, are certainly of equal antiquity to any in the Longmynd hills, and have the advantage of showing a base resting on a *pre*-Cambrian ridge, such as is nowhere shown in the Longmynds, or in North Wales. The accompanying section explains the relation of these beds to the *pre*-Cambrian islands at St. David's.

The life of this period, so far as we at present know, consisted of annelids, crustaceans, brachiopods, pteropods, and sponges. From 3000 to 4000 feet of these beds, in natural succession, have

SECTION OF CAMBRIAN ROCKS, ST. DAVID'S, SOUTH WALES.



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yielded fossils at St. David's, where as yet they have been chiefly examined. The Longmynd beds in Shropshire, in North Wales, and also in Ireland, have also yielded a few indications of life, but these districts need further exploration. Resting on these rocks at St. David's and in the Harlech district, we have a series of grey and blue flags and slates, with some sandstones at the upper part; and designated by Mr. Salter and myself the "Menevian Group." These beds are richly fossiliferous, and contain genera like those in the Longmynd Group below; several species are also common to the two groups. Between these two groups the boundary line separating Cambrian from Silurian was placed by Sir Roderick Murchison, and it is still retained here by the members of the Geological Survey. Lithologically there is a good deal of difference in these two groups, for the lower or Longmynd is almost invariably made up of green, purple, red, and grey rocks, and conglomerates; but palæontologically they are very nearly allied, and it would be in every respect wrong to place so strongly marked a divisional line between two groups so intimately connected by their organic contents. Sedgwick's line of division between the Middle and Lower Cambrian also comes in here, and from following lithological characters only. It may be granted, however, that there was some excuse for this boundary line, for at the time it was made no fossils had been found in the Longmynd Group. Henceforth, however, it will be impossible to retain this line, and I have therefore suggested that these two groups should go together to form Lower Cambrian, and that the line of division should be above instead of being below the Menevian Group. The genera and species of the Menevian group, also, are so thoroughly distinct from the immediately overlying rocks of the Lingula Flag group that the boundary seems to fall naturally at this spot.

17 genera and 25 species have been found in the Longmynd Group, and 23 genera and 52 species in the Menevian Group. Twelve genera and eight species are common to both groups, and such genera as *Paradoxides*, *Conocoryphe*, and *Microdiscus* are amongst them. This proportion is far greater than we usually find between two groups so dissimilar in lithological characters, and comprising so great a thickness of strata.

The next group we come to consists of what has usually been called the Lingula Flags, and so named from the abundance of

Lingulella Davisii found in some of the beds, chiefly the middle ones. This group has been divided into an *Upper*, *Middle*, and *Lower* series, each characterised by genera and species peculiar to that zone. On the whole, considering the thickness of the strata, which must be over 5000 feet, this group is exceedingly barren of organic remains. The Lower or Maentwrog beds contain only four genera and eight species; the Middle or Ffestiniog beds six genera and six species; and the Upper, Dolgelly or Malvern Shales, ten genera and eighteen species. The lithological characters are bluish or grey arenaceous slates for the Lower, grey arenaceous and micaceous flags for the Middle, and soft black and bluish slates for the Upper. The genera and species increase greatly in these Upper beds, as is usual with fine muddy deep sea deposits, though the thickness of the Upper beds is not more than 600 feet. We have in these last a return to conditions similar to those which followed the shore and shallow water deposits of the Longmynds during the depositions of the Menevian Group; but sufficient time had elapsed to change the prevailing forms of life, and yet not to an extent that they did not retain some resemblance to their ancient ancestors. All the trilobites of the Lingula Flags are allied to *Olenus*, and there are none in any way Silurian in character.

Following the Lingula Flags are the Tremadoc rocks. These occur chiefly in the neighbourhoods of Portmadoc, in North Wales, and of St. David's, in South Wales. They rest conformably on the Lingula Flags, and usually graduate by insensible degrees from them. They are more than 1,000 feet in thickness, and consist of dark earthy slates and flaggy sandstones. In the table they form the upper group of the Cambrian, a position given to them by the late Mr. Salter, and afterwards by Sir C. Lyell, and others. Mr. Salter, along with Messrs. Homfray and Ash, of Portmadoc, examined these rocks very carefully in North Wales, and proved that they formed an intermediate series in which Cambrian genera seemed to commingle in about an equal degree with Silurian genera. This has been borne out since by the researches conducted in the neighbourhood of St. David's, in South Wales, where a considerable addition to the fauna has been made; but here the trilobites, which in these early rocks are the surest indices of the age of the strata, are more strongly primordial in type, and tend to connect the group still more closely to the underlying series.

The Arenig Group, which comes in next in the Table, is divided into an *Upper* and a *Lower* series, both characterised by a distinct assemblage of fossils. The Lower series occurs chiefly in the neighbourhood of St. David's, and is of about 1,000 feet in thickness. The fossils consist of numerous graptolites, especially dendroid forms, and trilobites of the genera *Ogygia*, *Trinucleus*, and *Æglina*. All the forms are thoroughly Silurian in character, and the series marks a definite line for the base of the Silurian groups. The Upper series comprise the well known Skiddaw Slates. Upon the Arenig comes the Llandeilo Group, the lowest rocks recognised by Sir R. Murchison in the typical Llandeilo district. This group in the Table is divided also into an *Upper* and *Lower* series, marked out by distinct faunas.

The Bala or Caradoc Group now comes in with its exceedingly rich fauna, and it forms in the Table the upper member of our Lower Silurian, and also of Professor Sedgwick's Upper Cambrian. Sir R. Murchison added to the Lower Silurian the Lower Llandovery rocks, but Sir Charles Lyell in his "Student's Manual of Geology," 1871, preferred "to regard them as the base of the Upper Silurian, to which group they are linked by more than twice as many species as to the Lower Silurian." The evidence of Professor Hall and others, in America, tends to prove, however, that ultimately it will be necessary to make a Middle Silurian division, and though the group is scarcely important enough, as hitherto known in this country, to warrant such a division, yet should a spot be found where the present unconformity is filled up, a series may be discovered, like that in the American continent, sufficiently large to enable it to be done.

The higher groups, *Wenlock* and *Ludlow*, which complete the Table, are each capable of being divided into at least two groups, with a considerable thickness of strata and well defined faunas.

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2. On the Silurian Rocks of the English Lake District.

By H. Alleyne Nicholson, Esq., M.D., D.Sc., M.A., F.R.S.E., Professor of Natural History and Botany in University College, Toronto.

Considering the extent to which the Silurian series of the English Lake District has been studied, it is somewhat remarkable that there should still be considerable difference of opinion as to the

ages of its various members, their correlation with the deposits of other areas, and, in some cases, even their actual succession. In the following communication I propose briefly discussing this subject, and in so doing I shall speak of the following groups of strata :—

1. The Skiddaw Slates.
2. The Borrowdale Series, or Green Slates and Porphyries.
3. The Coniston Limestone and Associated Shales.
4. The Graptolitic Mudstones.
5. The Coniston Flags.
6. The Coniston Grits.
7. The Kendal Rocks.

I. The Skiddaw Slates.

The lowest sedimentary rocks of the Lake District are unquestionably those to which Professor Sedgwick applied the name of "Skiddaw Slates." This group comprises a great series of dark cleaved shales, with intercalated flaggy beds, which reach a total thickness of probably not less than about 7,000 feet. The upper beds of the series are generally readily distinguished from the lower, by being darker in colour, by being of a more fissile or shaly nature, and by being usually very imperfectly, or not at all, cleaved. As yet, however, no accurate line has been drawn between the upper and lower portions of the series, and some of the most characteristic fossils are common to both.

As to the relations of the Skiddaw Slates to the rocks which succeed them (the Borrowdale series), it has been generally believed that the highest beds of the Skiddaw series were conformably overlaid by the base of the Green Slates and Porphyries, and this opinion is still held by high authorities. I have endeavoured, however, to show (Geol. Mag., vol. vi., March, 1869) that this is not the case, and that the Skiddaw Slates are unconformably surmounted by the basement-beds of the Green Slate series. To this opinion I still adhere ; but having no fresh evidence to bring forward in support of my views, I need not press this point at present.

As regards the palæontological relations of the Skiddaw Slates, it has long been known that they contain a very rich and varied graptolitic fauna, comprising many peculiar forms. No less than nine genera and thirty-two species of graptolites have been de-

tected in the Skiddaw Slates; and five genera (viz., *Dichograpsus*, *Tetragrapsus*, *Loganograpsus*, *Phyllograpsus*, and *Trigonograpsus*), are exclusively confined to this horizon. All these genera, however, and a large number of the species, occur in the so-called "Quebec Group" of Canada; and there can, therefore, be no reasonable doubt as to the contemporaneity of the Skiddaw and Quebec groups. The most important fossils yielded by the Skiddaw Slates, besides graptolites, are, *Lingula brevis*, the peculiar phyllopod *Caryocaris Wrightii*, and the trilobites, *Æglina binodosa*, *Æglina caliginosa*, *Agnostus Morei*, *Phacops Nicholsoni*, and *Trinucleus Gibbsii*.

In applying the stratigraphical and palæontological elements at our disposal to the solution of the question of the *age* of the Skiddaw Slates, we find ourselves beset with unusual difficulties. The physical evidence only tells us with certainty that the Skiddaw Slates underlie strata which at the utmost cannot be older than the Llandeilo Flags of Wales. If the Skiddaw Slates were conformable to these, there would be the probability that the Skiddaw series is not older than the Arenig rocks of Wales, as is believed by Professor Harkness. Even in this case, however, the Skiddaw Slates can hardly be said to be the *equivalent* of the Arenig group, as the latter contains none of the peculiar graptolites of the former. If, on the other hand, the Borrowdale series (as I believe), rests unconformably upon the Skiddaw series, there is a high probability that the latter is older than the Arenig, and that it corresponds to part of the Upper Cam[1] rians. The palæontological evidence, though more satisfactory than the physical, still leaves much to be desired. The great majority of the Skiddaw graptolites occur in no other British formation, and do not, therefore, supply any element of comparison so far as Britain is concerned. No stress, also, can be laid upon the occurrence of some four or five of the Skiddaw graptolites in the Arenig and Llandeilo deposits of Wales. The phyllopod *Caryocaris Wrightii*, so abundant throughout the whole Skiddaw series, is also peculiar to this horizon, and affords, therefore, no means of comparison. The trilobites, on the contrary, belong to the Silurian genera, or at least to genera all of which are represented in the Silurian series. The genus *Phacops*, in particular, has not yet been detected in rocks undoubtedly older than the Silurian. There are no "primordial" trilobites; and the evidence, therefore, to be drawn from these

crustaceans would lead us to believe that the Skiddaw Slates are referable to the Lower Silurian series.

On one point only do the fossils of the Skiddaw series speak with certainty, and that is as to the equivalency of the British formation with the Quebec Group of Canada. All the peculiar genera of graptolites in the Skiddaw Slates occur also in the Quebec Group, and in Canada, as in Britain, they do not occur in any younger formation, with rare exceptions. At least half of the Skiddaw *species* are also identical with Canadian forms. We may, therefore, safely conclude that the Skiddaw and Quebec groups are "contemporaneous" deposits, in the geological sense of this term. It follows from this that the age of the Skiddaw Slates might be fixed without difficulty, if only the age of the Quebec Group were known with certainty. Unfortunately, however, the precise age of the Quebec rocks is still a matter of opinion, for they contain a mixture of "primordial" fossils with genuine Silurian types, and their stratigraphical position is also somewhat uncertain. As regards the first of these points, we meet in the Quebec Group with the Silurian genera *Asaphus*, *Cheirurus*, *Illœnus*, and *Lichas*, mingled with "primordial" trilobites of the genera *Dikelocephalus*, *Menocephalus*, *Bathyurus*, and *Bathyurellus*. The brachiopods, gasteropods, and cephalopods are, on the other hand, referable to types which are characteristic of the Lower Silurians. The Quebec Group has generally been regarded as belonging to the same formation as the Calciferous Sand-rock of the State of New York, which immediately overlies the Potsdam Sandstone, and the age of which appears to be indubitably Upper Cambrian. In Newfoundland, however, the Quebec Group ("Lévis formation") has been described as being separated from the "Calciferous" by over two thousand feet of other strata. If there be no disturbance of the strata this would show that the Quebec Group is considerably younger than the Calciferous; but it is not impossible that the phenomena admit of some other explanation.

II. Borrowdale Series.

Overlying the Skiddaw Slates comes the great series of rocks termed by Professor Sedgwick the "Green Slates and Porphyries," for which the name of "Borrowdale Rocks" has been proposed by Professor Harkness and myself. These consist essentially of a vast succession of bedded traps and porphyries, with stratified felspathic

ashes, breccias, and amygdaloids. The great mass of the series is of igneous origin, but I am unable to agree with Professor Ramsay in believing that the rocks of this series are sub-aerial. It is with great diffidence that I differ from so distinguished an authority, but I am decidedly of opinion that the traps of this series were poured out beneath the sea, and that the ashes have been subjected (in most instances at any rate) to the sorting action of water.

Near the summit of the Borrowdale series there is found a thin group of beds, sometimes of an ashy, sometimes of a shaly nature, which have been shown to contain in places a number of ill-preserved fossils. These beds, beyond all question, underlie the Coniston Limestone, from which they are separated by a mass of trap, and they are, therefore, truly a portion of the series of the Green Slates and Porphyries. Amongst the fossils which they contain may be mentioned *Petraia subduplicata*, *Calymene Blumenbachii*, *Orthis vespertilio*, *Orthis flabellulum*, and *Strophomena tenuistriata*. These fossils leave little doubt but that the upper portion at any rate, if not the whole, of the Borrowdale series is referable to the Caradoc or Bala period.

Beyond the limits of the Lake District proper, a remarkable series of fossiliferous beds has been described by Professor Harkness as occurring beneath the Penine Chain, under the name of the "Dufton Shales." These beds are replete with Bala fossils, and their age is thus rendered indisputable. Their stratigraphical position, however, is not so certain. By Professor Harkness they are regarded as belonging to the series of the Green Slates and Porphyries, as underlying the Coniston Limestone, and as corresponding to the thin fossiliferous band found in the Lake District, near the summit of the Borrowdale series. After a careful and repeated examination of the district in question, I have been led to entirely adopt the views of Professor Harkness upon this subject; but I believe that Mr. Hughes is of the opinion that these beds are not truly referable to the Green Slate series. No such doubt, however, can, in my opinion, be entertained as to the position of certain other fossiliferous beds which were described by myself under the name of "Swindale Shales." These beds occur in the same Silurian area beneath the Penine Chain, but they are inferior in position to the Dufton Shales, and I feel no hesitation in considering them as a portion of the Green Slate series. They occur in the course of Swindale Beck, near the village of Knock,

in Westmoreland, and they consist of brownish ashy beds, with black flaggy shales, and green and purple slates. They contain numerous fossils, which belong to common Caradoc types, and which are in most instances identical with the organic remains of the "Dufton Shales." Apart, therefore, from the evidence afforded by the thin fossiliferous band in the Green Slates of the Lake District, I think we have satisfactory grounds for believing that the entire Borrowdale series, or group of the Green Slates and Porphyries, is of the age of the Caradoc beds of Wales.

III. Coniston Limestone.

Overlying the Borrowdale Series with perfect conformity, we have the formation described by Prof. Sedgwick under the name of the "Coniston Limestone." This consists, in the Lake District proper, of several bands of limestone separated by intercalated hard gray or bluish cleaved shales. It is unnecessary to consider the fossils of the Coniston Limestone, as it is universally conceded that this formation is the equivalent of the Bala Limestone of Wales. In the neighbourhood of Sedbergh, however, Mr. Hughes has shown that the Coniston Limestone passes upwards into a considerable thickness of shaly beds, which he terms "Trinucleus Shales" and "Strophomena Shales," from the occurrence in them of *Trinucleus concentricus* and a large species of *Strophomena*. I had the pleasure of examining these beds under the guidance of Mr. Hughes, but I am disposed to regard them as nothing more than a great development of some of the shale-beds which are universally present in the Coniston Limestone in the Lake District. It is quite certain that in the Lake District proper the bands of limestone extend to close upon the summit of the series; and the "Strophomena and Trinucleus Shales" of Mr. Hughes, if not altogether absent, are at most represented by no more than a few feet of fossiliferous shales. West of Coniston Lake, however, the series assumes more the character which it exhibits in the Sedbergh district; and in the extreme west, in the neighbourhood of Millom, there is a considerable mass of shale overlying the highest bed of actual limestone. It does not appear to me, however, that any satisfactory separation, physical or palæontological, can be made between the limestone and these overlying shales, and I should be disposed to group both under the name of "Coniston Limestone."

IV. Graptolitic Mudstones.

Immediately above the Coniston Limestone, and as far as the present evidence goes, surmounting it with entire conformity, comes a small but remarkable group of beds which have been described by Professor Harkness and myself under the name of the "Graptolitic Mudstones." These beds consist of a series of black and grey shales and mudstones charged with the remains of graptolites. As no graptolite has hitherto been discovered in the richly fossiliferous shales associated with the Coniston Limestone (though their nature is such that graptolites might well be expected to occur in them), the contrast between these and the immediately overlying and contiguous mudstones is of an exceedingly striking nature. The graptolites of the Mudstones, though in many cases peculiar to this horizon, are in the main wonderfully similar to those of the Upper Llandeilo shales of Dumfriesshire, including species of the genera *Diplograpsus*, *Climacograpsus*, and *Rastrites*. Besides graptolites, they have only yielded *Endoceras proteiforme* of the Lower Silurian rocks of North America; the Bala fossils *Sphæronites punctatus* and *Orthis calligramma* (*?*), and some undescribed crustaceans and orthocerata. As to the age of these beds there is still some difference of opinion. For my own part, I still adhere to the opinion originally expressed by Professor Harkness and myself, that the Graptolitic Mudstones are of unequivocal Lower Silurian age. I consider that this is placed beyond all question by the character of the graptolites. At the same time I am prepared to abandon the view which I formerly held, that the Graptolitic Mudstones form a portion of the series of the Coniston Flags. On the contrary, the researches of Mr. Hughes seem to have conclusively shown that the Coniston Flags are essentially distinct from the Graptolitic Mudstones, though I am not aware that in any instance the stratigraphical relations between the two have as yet been satisfactorily determined. I need only add that whilst the Graptolitic Mudstones rest in the Lake District upon the Coniston Limestone itself, they repose in the Sedbergh District upon the "Trinucleus and Strophomena Shales" of Mr. Hughes. Superiorly, the Graptolitic Mudstones appear to pass upwards with complete conformity into the ordinary Coniston Flags, and I have never been able to detect any sign of a discordance between the two. Still, the actual junction between

these formations has not yet, so far as I am aware, been observed; and there is thus some room for doubt as to the relations which subsist between the two. There is, also, undoubtedly a marked change in the fauna, which is especially noticeable as regards the graptolites. Thus, the Graptolitic Mudstones contain numerous species of *Diplograpsus*, along with examples of the genera *Climacograpsus* and *Rastrites*; and the great majority of the specific forms (when not peculiar to this horizon) are identical with well-known forms from the Upper Llandeilo shales of Dumfriesshire. On the other hand, the Coniston Flags proper have yielded no specimens referable to the above-mentioned genera, and contain only examples of the two genera *Retiolites* and *Graptolites*, both of which pass up to the very summit of the Silurian Series.

V. The Coniston Flags.

The Graptolitic Mudstones are succeeded upwards, whether conformably or not is a matter of opinion, by the "Coniston Flags" of Professor Sedgwick, consisting of about 2,000 feet of cleaved flags, mostly of a very dark grey or black colour. As I have just remarked, the Coniston Flags were formerly made by Professor Harkness and myself to include the Graptolitic Mudstones; but I am now of opinion that this view cannot be sustained; and it is to the researches of Mr. Hughes that this change in my views is chiefly due. The true relations of the Coniston Flags, however, are, in my opinion, still uncertain; and I do not think that there is yet sufficient evidence to warrant us in asserting positively that they are of Upper Silurian age. Their contained fossils yield very little decisive evidence, consisting chiefly of orthocerata and graptolites. As regards the latter, the most important point is the absence, so far as is yet known, of any diprionidian form. The only species which the Flags contain are *Graptolites Sedgwickii*, *G. priodon*, *G. colonus*, and *Retiolites Geinitzianus*. Of these, the first three certainly occur in the Graptolitic Mudstones, and there is some evidence of the existence in this formation of even the last. On the other hand, all but *G. Sedgwickii* are known as characteristic fossils of the Wenlock and Ludlow formations elsewhere. The most decisive ground, however, for adopting the view of Mr. Hughes—that the Coniston Flags belong to the Upper Silurian series—is to be found in the fact that the Flags un-

doubtedly pass upwards with entire conformity into the series of the Coniston Grits; and his discoveries leave no room for doubt as to the Upper Silurian age of this latter group. Upon the whole, therefore, the balance of evidence at present seems to be in favour of the view that the Coniston Flags truly appertain to the Upper Silurian Series.

VI. Coniston Grits.

The Coniston Flags graduate upwards into a great series of grits, slaty, shaly, and arenaceous beds, originally termed the "Coniston Grits" by Professor Sedgwick. As just mentioned, the discoveries of Mr. Hughes have rendered it certain that the Coniston Grits are of Upper Silurian age. This is shown by the occurrence of such forms as *Spirorbis Lewisii*, *Orthoceras Ludense*, *Ceratiocaris Murchisoni*, *Beyrichia Kloedeni*, *Phacops Downingiæ*, and *Rhynchonella navicula*. There are also grounds for believing that the Coniston Grits are not to be placed very low down in the Upper Silurian series; but their correlation with the type-series of Wales is still uncertain. Under any circumstances no more important step in unravelling the complicated Silurian series of the Lake District has been made of late years than the discovery that the Coniston Grits are of Upper Silurian age.

VII. Kendal Rocks.

The Coniston Grits, finally, are succeeded by a great series of shales, grits, and flags, which are largely developed in the neighbourhood of Kendal, and may therefore appropriately retain the local name of the "Kendal Rocks." The thickness of these beds is very great—apparently not less than four or five thousand feet—and they contain numerous fossils of the ordinary Ludlow type. There is, therefore, no hesitation in regarding the Kendal Rocks as being of Upper Silurian age, and as corresponding with the Ludlow Rocks of Wales. If, however, we are to admit that the Coniston Grits and Coniston Flags are likewise of Upper Silurian age, we have to allow that the Upper Silurian series of the North of England has the unprecedented thickness of at least ten thousand feet—more than double the thickness of the Upper Silurians of "Siluria." And if, as seems probable, the Coniston Grits are referable to the Ludlow rather than to the Wenlock, then we shall have to admit

that the Ludlow formation of the north of England has the enormous thickness of about eight thousand feet, the corresponding strata in Wales not reaching a thickness of two thousand feet. We may confidently expect, however, that future discoveries will enable us to reason with greater certainty on these and other similar points which now are more or less obscure.

EXCURSION TO BROMLEY AND CHISLEHURST.

JUNE 15TH, 1872.

Directors.—JAMES W. ILOTT, Esq., and COLES CHILD, Esq., F.G.S.

This excursion was rendered noteworthy by the large attendance of Members, who quite filled the railway station at Shortlands, at which place the party left the train in order to visit the neighbouring West Kent Water Works, where a well had recently been sunk into the Chalk. The well had been completed with highly successful results, a most abundant supply of excellent water having been obtained. The resident engineer, Mr. Morris, kindly described the operations, and exhibited a detailed section of the well. Walking along the railway the Members attentively examined the sections of the Pebble-beds of the Woolwich Series, near Bromley Station, and then entered the park of Bromley Palace, the residence of Mr. Coles Child, and under that gentleman's guidance inspected a section of the Shell-beds of the Woolwich Series, exposing a bed nearly entirely composed of *Cyrena*, with another bed made up of *Ostrea*.

Mr. Child hospitably entertained the party in the beautiful gardens of the Palace, in which some of the evergreens are of remarkable size, and then led the way to his brick-works at Widmore, where an interesting section of the Woolwich Series with a capping of what may represent the Basement-bed of the London Clay is exposed. The lower beds have yielded plant remains in a fine state of preservation. A pleasant walk through Sundridge Park brought the party to the well-known section of the Woolwich Series in the woods of this beautiful domain, in which the *Cyrena* and *Ostrea* are found together, and not in separate beds as at the section previously mentioned. The lodge at the park gates is built of material from these beds, and the abundance of fossil shells displayed gives to the structure a very curious and picturesque appearance.

Leaving Sundridge Park the party proceeded to the caves or excavations in the Chalk under Camden Park, which ramify and extend to a considerable distance from the entrance. Nathaniel Strode, Esq., the owner of Camden Park, had with great courtesy caused the caves to be illuminated for the occasion, and thus the Members were enabled to observe the structure of the Chalk as displayed in the numerous faces of these branching excavations. Mr. Ilott narrated his discovery of ancient excavations and antiquities at this place, where, as at many other localities in this part of Kent, cavernous hollows in the Chalk have existed since the times of the pre-historic inhabitants of Britain.

Leaving the Chalk Caves, the party walked to Chislehurst village, by way of Camden Park, and after a little time devoted to rest and refreshment, returned to London from Chislehurst Station.

EXCURSION TO HENDON AND FINCHLEY.

JUNE 22ND, 1872.

Director.—HENRY HICKS, ESQ., F.G.S.

A party of about fifty assembled at Hendon Station, and at once proceeded to the village of Hendon, situated upon the high ground, to the east. The London clay is here capped by Glacial deposits, which form the summits of the eminences lying between the Bagshot outliers of Hampstead and Highgate, and the elevations of London Clay extending along the borders of Middlesex and Hertfordshire.

Dr. Hicks led the way to some recently excavated pits, where good sections were exposed. Here he pointed out to the party the very marked resemblance of the beds at this place to the Thames low-level sands and gravels of Post Glacial age. At a little distance from this place a large marquee had been erected, and luncheon provided by James Campbell, Esq., of The Grove, Hendon, to whom subsequently a cordial vote of thanks was given for his liberality.

The Members then proceeded to the residence of Dr. Hicks, who had arranged his far-famed collection of Cambrian and Lower Silurian fossils on tables in his grounds for the inspection of his visitors. The large trilobites *Paradoxides Davidis*, and *P. Hicksii*, from the Menevian rocks of St. David's, attracted great attention, and the number, variety, and good preservation of the Cambrian

fossils surprised many of the visitors who were not familiar with Dr. Hicks's important discoveries of organisms in the oldest fossil-bearing rocks of the British Islands.

Leaving the attractive collection the party followed for a short distance the lane leading to Finchley, and then turned aside to some extensive excavations where the Glacial beds were exposed to a great depth, and the underlying London Clay was seen in a sinking at the bottom of the pit. Here the "Middle Glacial" of Mr. Searles Wood is seen underlying the "Chalky Boulder Clay," which forms the upper portion of the section. Mr. Caleb Evans and Mr. C. J. A. Meÿer briefly described the geology of the district, and discussed the origin of Sarsen stones, some of which masses of quartzite were lying around.

After a pleasant walk of about a mile Finchley was reached, and the interesting exposures of Glacial deposits near the village were subjected to examination. These are described in Mr. Henry Walker's paper "On the Glacial Drifts of North London" (Proc. Geol. Assoc., vol. ii., p. 289). Derived fossils, especially *Gryphæa incurva*, from the Lower Lias, are abundant, and some time was spent in obtaining specimens of these suggestive memorials of great terrestrial changes.

ORDINARY MEETING, JULY 5TH, 1872.

JAMES W. ILOTT, ESQ., in the Chair.

The following Donations were announced :—

"Abstract of the Proceedings of the Geological Society," from that Society.

"On the Diamond Gravels of the Vaal River, South Africa," by G. W. Stow, from Prof. T. Rupert Jones, F.R.S.

"Notes on the Rhætic Sections, Newbridge Hill," by the Rev. H. H. Winwood, M.A., F.G.S., from the Author.

"The Study of Geology, an Introductory Lecture," by J. Logan Lobley, F.G.S., from the Author.

"Communications to the Monthly Meetings of the Yorkshire Philosophical Society," from that Society.

"Notices of the Life of Sir Roderick Murchison," by General Helmerson, from Mrs. E. Cattley.

The following were elected Members of the Association :—

George E. Cooke, Esq.; William Alfred Duck, Esq.; Henry English, Esq.; George Berringer Hall, Esq.; and Robert Swan, Esq.

The following Papers were read :—

1. On Corbicula fluminalis, its Associates and Distribution in Britain.

By Alfred Bell, Esq.

(This Paper has been withdrawn by permission of the General Committee.)

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2. Note on Specimens of Ptychodus latissimus, from the Chalk of Grays, Essex.

By Owen Rees, Esq., F.G.S.

(Abstract.)

In a recent excavation in the great chalk pit at Grays, at a depth of seven or eight feet from the general level of the bottom of the pit, large specimens of *Ptychodus latissimus* had been found. The chalk in which these so-called palatal teeth occurred was very compact, and much more valuable commercially than the chalk of the higher beds.

The following are the dimensions of some of the teeth :—

The largest..... 2¼in. by 1⅝in.
The next largest..... 2⅛in. by 1⅜in.
An average specimen 1¼in. by 1⅛in.
The smallest ..... 0¾in. by 0½in.

The author bore testimony to the cordiality with which the late Mr. Meeson invariably welcomed any geologists desirous of examining the sections exposed in his extensive pits at Grays.

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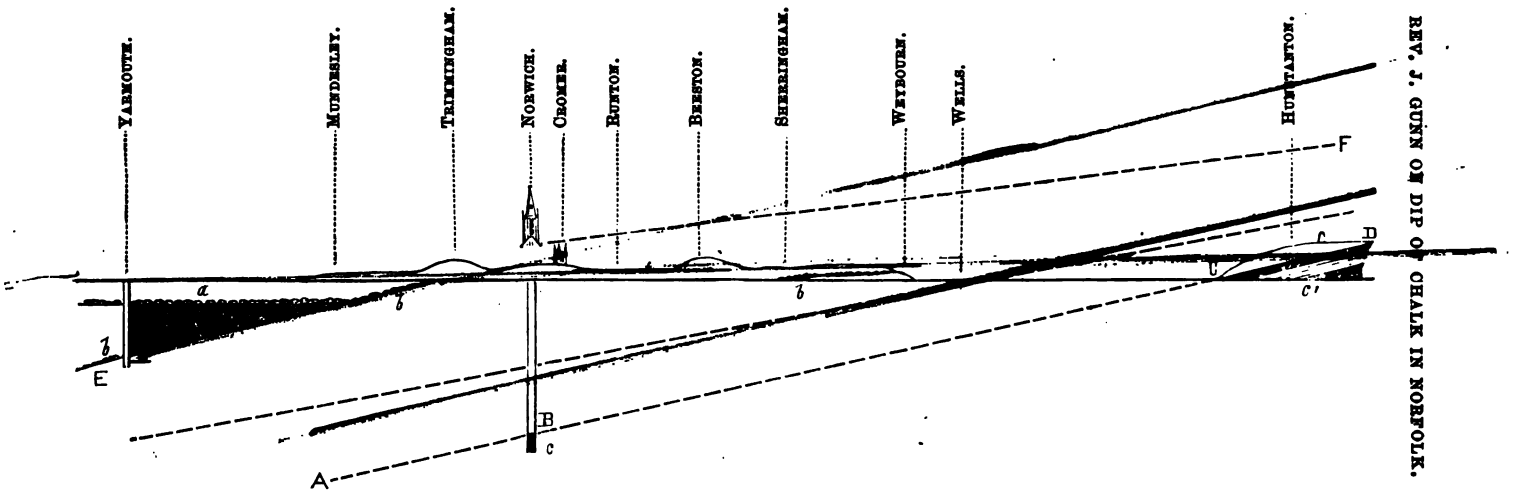
3. On the Dip of the Chalk in Norfolk, and the Remains of Old Land Surfaces called the Stone-Bed.

By the Rev. John Gunn, M.A., F.G.S.

The dip of the Chalk from Norwich to Yarmouth is ascertained by measurement of its surface from the high-water level at Norwich to Sir E. Lacon's brewery at Yarmouth, where on sinking an artesian well, the Chalk was found to be 526 feet beneath the high

SECTION SHOWING THE DIP OF THE CHALK IN NORFOLK, AND THE POSITION OF THE "STONE BED."



a Bone-bed on surface of London Clay. *b* Stone-bed on surface of Chalk.

Yarmouth to Norwich 18 miles. Norwich to Hunstanton 40 miles. Cromer to Hunstanton 33 miles. Dip of Upper Chalk from Norwich to Yarmouth 29 feet per mile. Dip of Chalk from Norwich to Hunstanton nearly 29 feet per mile. Dip of Chalk Marl 36 feet per mile and a quarter.

water level; and by dividing 526 feet by 18, the number of miles from Norwich to Yarmouth, the dip is given about 29 feet per mile.

The surface of the Chalk from Norwich to Hunstanton is so denuded that it does not admit of any measurement or computation. The lowest portion of the Chalk, viz., the Chalk Marl (marked A. D.) is, therefore, chosen as the basis, and the dip of it from the high water mark at Hunstanton, where the Chalk Marl rises above that water line at (C) to Mr. Colman's artesian well (marked B) is easily ascertained. The Chalk Marl is there 1152 feet deep; and if we divide 1152 feet by 40, the number of miles from Norwich to Hunstanton, nearly 29 feet per mile also will be given as the dip of the Chalk Marl, singularly agreeing with the dip of the Upper Chalk with flints from Norwich to Yarmouth.

The dip of the Chalk Marl from the high water mark at Hunstanton (C) to where it crops out near the Hunstanton lighthouse (marked D), which admits of actual measurement, also corresponds, being 36 feet in about a mile and a quarter.

The upper surface of the Chalk presents an old land surface, or rather series of land surfaces, which have been successively covered, stage by stage as it were, by beds commencing with the London Clay and Lower Tertiaries, some Miocene or Diestien beds, the Forest-bed series, the Crag series, the Laminated or Chillesford Clay series, the Lower Boulder Clay, the Middle Drift, the Upper Boulder Clay, and the Post-glacial Beds.

The portions of this land-surface of the Chalk with flints, which have been from time to time subaerial, have been acted upon by the rain and atmospheric influences; and the stones washed out of it have formed what is called the "Stone-bed." The animals which dwelt from time to time upon the old land surface have their remains intermingled. Thus the *Mastodon arvernensis* and *Elephas meridionalis* are found in the same portion of the Stone-bed, notwithstanding that long intervals of time may have elapsed between them. The Mastodon is, there can be little doubt, derived from older beds, and has never been found in the Forest-bed, which abounds with the *Elephas meridionalis*.

In the higher parts of the Stone-bed, the remains of more recent animals appear, and the abundance of the horns of the *Cervus elephas*, together with bones of the ox and horse, is very remarkable. The highest parts of the Chalk probably remained uncovered till after the Upper Boulder Clay was deposited, when all Norfolk,

not excepting the highest hills, appears to have been submerged beneath what is called a glacial sea.

The denudation of the Chalk with flints (E to F) by atmospheric agencies was, it may be presumed, gradual and slowly progressive; while in some districts—as Weybourn, Wells, and Thornham—the action of fluviatile and marine currents was violent and rapid; but the result is that the several beds of Chalk, which, if uniformly and horizontally deposited, were 1,126 feet in thickness, have been wasted and denuded so that they rise only 36 feet above the Upper Greensand, or the Gault at Hunstanton (marked D).

It is most probable that the Chalk was deposited within a basin of the Lower Greensand; but it is evident from the large bouldered masses of Chalk with flints (about 50 feet long) at North Wootton Common, near Lynn, that the Upper Chalk has been laid down, and has been washed away, and that the *débris* of flints, Lower Greensand, and Gault, may have supplied the enormous accumulations of sand, gravel, and clay visible in the Norfolk cliffs. "Whence could these masses of sand, gravel, and clay have been derived?" was the exclamation of Dr. Falconer when he inspected those cliffs on the Eastern coast. The answer is obvious,—From the denudation of parts of the Cretaceous Series.

The fact that the gravel of East Norfolk is derived from similar beds of Chalk with flints to that at Trimmingham, is obvious from the similarity between the flints in both.

The diagram serves also to explain the difference between the Bone-bed in Suffolk, described by Mr. Ray Lankester, and the Stone-bed of Norfolk, namely, that the Bone-bed is laid down upon the surface of the London Clay, and contains the *débris* of Miocene beds, whereas the Stone-bed is laid down upon the Chalk, and contains the *débris* of beds which yielded the *Mastodon arvernensis*, and also the successive remains of fauna from that remote period to recent times.

It is a growing conviction on my mind that the *Mastodon arvernensis* is derived from, and belongs to, some Antwerp beds, possibly of the Miocene period; or, like the bed at Pikermi, in Greece, intermediate between the Miocene and older Pliocene; and the soil of the Forest-bed, which contains the *Elephas meridionalis* in all the rugosity and thickness of the enamel of the teeth, approximating to the Mastodon, must be referred to the older Pliocene. The repeated elevations and subsidences of the land during the Forest-

bed epoch, and the extraordinary changes and variety of the forms of deers' horns in that series, compared with the permanence of those forms from Post-glacial times to the present day, claim an immense duration for the Forest-bed, far greater than has been assigned to it; whereas there was a continued subsidence of the land, from that period, throughout the Crag, Chillesford Sands and Clay, and the Lower Boulder Clay epochs, after which the land appears to have been re-elevated.

All the changes of the fauna are faithfully represented in the Stone-bed, the more ancient being occasionally found on the inclined plane of the Chalk, upon which the animals may have lived; but the more recent are never found in the older parts of the Stone-bed. It is hoped, therefore, that the study of this deposit may tend to assign the mammals to their true places, as it has already served to despoil the Norwich Crag of nearly all its mammalian remains. A few years ago the *Mastodon arvernensis*, and *Elephas meridionalis*, and many others, were confidently affirmed to belong to it; but now it is proved to be nearly non-mammaliferous.*

* Since writing the above, the Author, in a paper read at the meeting of the British Association at Bradford, has applied the established fact of the upheaval of the Chalk from Yarmouth to Hunstanton to the amount of 1678 feet, to establish another fact of paramount importance, namely, that, together with the Chalk, there must have been a corresponding upheaval of the Palæozoic rocks, and, consequently, an increased proximity to the surface of the Carboniferous beds, if they existed there. A very interesting corollary to this is, that at the Harwich boring the Posidonomya bed, which immediately underlies the true coal, and is there proved to be 1026 feet beneath the water level, if a similar upheaval to that from Yarmouth to Hunstanton had taken place would have been raised 652 feet above the present surface of the land. To what height the Carboniferous strata above, if any once existed, might have been carried is only a matter of conjecture; but, as the dip of the beds is supposed to be northerly, they would have occupied the Anglo-Belgian Basin, and have been brought nearer to the surface again by the elevation of the land at Hunstanton and in the neighbourhood of Lynn. This forms one of the grounds upon which Mr. Gunn advocates an experimental boring for coals at one of those places.

order of succession of the Lower Silurian and Cambrian rocks of South Wales, which he knows so well, and which he had been re-examining during the previous fortnight. Some of these rocks Dr. Hicks considers have representatives in the beds of the Longmynds. The Llandovery conglomerates lying on the uptilted beds of the Cambrians, at an angle of 22 degs., were well seen on the eastern slope of the hill, and the "Pentamerus Limestone," with its characteristic *Pentamerus oblongus*, was also found. The quarries of Caradoc rock in the Onny valley were then visited, and at one of these Professor Morris gave a general description of the Silurian System of Murchison, and pointed out the extension in England of its various members.

Friday was occupied by a journey in carriages to the mining district of Shelve, and by an inspection of the very interesting hill country between that place and Church Stretton. On the road to Shelve quarries in the Cambrian rocks at the south end of the Longmynds, and in the Llandovery beds near Marbury, occasioned stoppages, during which the hammers of the Members were vigorously used. A visit was then paid to Jasper More, Esq., of Linley Hall, who courteously invited the party to inspect his fine model of the South Shropshire mining district, the famous pig of lead of Roman age, with the name of the Emperor Hadrian upon it, found near Shelve, and specimens of the mineral products of the locality of extraordinary size and beauty. The Members were entertained at luncheon, and after complimentary speeches by Professor Morris and Mr. More, the party left Linley Hall, and proceeded by a long, narrow, and very beautiful valley in the park terminating near the end of the Stiperstones. Outside of Linley Park a mass of felspathic ash in Lower Llandeilo rocks is being quarried for road metal, and the Llandeilo beds, thus laid bare, were eagerly and most successfully searched for fossils. After a brief visit to the White Grit Mine the carriages were finally left, and the party commenced the ascent of the Stiperstones ridge, from the summit of which is seen a fine panorama of the Welsh mountains, with the old volcanic Corndon in the foreground, and Plinlimmon and Cader Idris in the extreme distance. The extraordinary masses of obtruding, hard, white quartzite rocks, called the Stiperstones, were objects of great interest, and occasioned considerable discussion, some of the Members not being satisfied with the evidence adduced to show that they were the equivalent

well seen at Bawdsey Cliff, as pointed out by Mr. S. V. Wood, in his "Supplement to the Crag Mollusca" (Pal. Soc.), p. v. In the Walton Naze section, oblique lamination and false bedding are conspicuous features.

The palæontology of the Red Crag has been carefully studied by Mr. Alfred Bell, who, in his paper "On the English Crags" (Proc. Geol. Assoc., vol. ii., p. 185), enumerates 170 species from the Walton Naze deposit, of which 116 species are found also in the Coralline Crag. This large proportion of species common to the two deposits is very noteworthy, and when it is also found that there is an absence from the Walton Crag of several forms occurring in the Red Crag of other localities, the evidence is strong for considering the Walton Naze deposit to be older than the Red Crag of Suffolk. After examining the cliffs for a considerable distance along the coast, the Members returned to Walton, where they dined together, and then took the train for London.

VISIT TO THE INTERNATIONAL EXHIBITION.

JULY 13TH, 1872.

Directors:—Professor TENNANT, F.G.S., &c., and RICHARD DAINTREE, Esq., F.G.S.

The object of this visit was to inspect the fossils, ores and other minerals from the Colony of Queensland, which had been brought together by Mr. R. Daintree, F.G.S., and the specimens of gems in the jewellery department of the Exhibition.

Having assembled in the Queensland Annexe, the visitors were addressed by Mr. Daintree, who described the fossils and minerals which indicate the wealth of Queensland, both in coal and metals; and gave an interesting account of the physical features of the Colony. A nugget of gold, valued at £500, attracted great attention, and the large masses of native copper, as well as the splendid slabs of malachite (green carbonate of copper), convinced the Members of the great abundance of copper in Queensland.

After thanking Mr. Daintree for his instructive lecture, the party left the Queensland Annexe, and followed Professor Tennant to the collections of jewellery, and listened with great interest to his lucid remarks on the gems of which there were exhibited so

many fine examples. The attention of the visitors was then drawn to the specimens of imitation gems, and the characters by which real stones may be distinguished from false were described. The Professor subsequently led the way to the Gem Collection in the South Kensington Museum, and then pointed out the most remarkable and curious stones and pearls of that fine collection. The cordial thanks of the visitors were given to Professor Tennant for his lecture, and for his courteous attention to the many questions of his hearers.

EXCURSION TO LUDLOW AND THE LONGMYNDS, JULY 22ND TO 27TH, 1872.

Directors:—Professor MORRIS, F.G.S., Hon. Memb. Geol. Assoc., the Rev. J. D. LA TOUCHE, B.A., and ROBERT LIGHTBODY, Esq., F.G.S.

After the Members had assembled in Ludlow Castle, the Upper Ludlow rocks on the right bank of the Teme were examined, and Mr. Lightbody gave his reasons for considering the "Aymestry Limestone" to be represented at a point near the old bridge, although the species usually found in that rock, the *Pentamerus Knightii*, is not found here. The Upper Ludlow contains *Chonetes lata* in great abundance, and scarcely a fragment of the rock was picked up without this species being seen upon the surface. From the high ground by the river side the valley of the Teme may be advantageously seen. The river here flows through a gorge in the Upper Ludlow rocks, with the castle and the town of Ludlow on the left bank, while the "Old Red" country extends beyond to the Clee Hills, the igneous summits of which commandingly rise to the east, surrounded by the Coal Measures. The well-known section in Ludford-lane, showing the "Bone-bed," was then visited. This "Bone-bed," or "gingerbread" as it is sometimes called from its appearance, is in places not more than a quarter of an inch thick, and is found only after careful search. The fragments of the remains of fish which it contains were, until comparatively recently, the oldest fish remains known.

The following day (Tuesday) was devoted to an examination of sections of the Aymestry Limestone, Lower Ludlow, and Wenlock rocks, occurring in the course of a route of about twenty miles.

The journey was performed by means of carriages, but abundant occupation was given for the hammers of the party at the various exposures of the above named richly fossiliferous rocks. Graptolites from the Lower Ludlow, near Leintwardine were obtained in abundance, and fine specimens of the trilobite *Phacops longicaudatus* were found in the Wenlock Shale exposed in the bed of the Teme near Burrington, while *Pentamerus Knightii* was seen in great profusion in the Aymestry Limestone of Mocktree. Near the Comus Wood (so-called from being the scene of Milton's "Comus") a most extensive view is obtained of the country to the south east embracing the Old Red Sandstone district of Herefordshire, with the Malverns very distinctly seen in the distance. In the evening the Members were entertained at a soirée, given by Humphrey Salway, Esq., of The Cliff, Ludlow.

During Wednesday the Upper Ludlow rocks in the valley of the Teme were subjected to further examination. The party proceeded to Downton, where the uppermost members of the series are seen at the Tin Mills section. From one point on the road to Downton the physiography of the district to the north of Ludlow is well seen, and here Professor Morris pointed out the principal features of the extensive landscape, and showed how entirely they were due to their geological structure, the hills and ridges being formed of hard limestone, and the valleys scooped out of softer strata which had not so successfully resisted denudation, while the Coal Measures of the Clee Hills had been preserved by the old volcanic outbursts which had formed the central masses of hard "dhustone" composing the summits and cores of these lofty hills.

On Thursday the party ascended the Longmynds at their southern extremity, where masses of quartzose conglomerate, of Cambrian age, protrude from the surface, and speak to us of sea shores and rolling waves and fresh sea breezes, at a time so distant that the pyramids of Egypt and all man's most ancient works are but things of yesterday compared with the little pebbles to which those waves gave their present rounded form, and which we hammer out of the grey projecting rocks under which the sheep of the Longmynds shelter from the storms of to-day. The Rev. Mr. La Touche described the topography and the geology of the district seen from the elevated ground on which his hearers were assembled; and subsequently Dr. Hicks, F.G.S., explained the

EXCURSION TO WALTON-ON-THE-NAZE.

JULY 8TH, 1872.

Director :—J. LOGAN LOBLEY, ESQ., F.G.S.

The Pliocene formation known as the Red Crag, though presenting a greater extension in the county of Suffolk, is well exposed on the coast of Essex, in the low cliffs north of Walton-on-the-Naze, where it occurs as an outlier from the main mass. Walton, being a very accessible locality to residents in the metropolis, was selected as the locality for the examination of this division of the Crag deposits of East Anglia.

The town of Walton-on-the-Naze is situated on the London Clay, which here forms low elevations, and is well exposed in the sea cliffs immediately to the south. Further southwards the London Clay is covered by deposits to which Mr. Searles V. Wood gives the name "Post Glacial Valley Beds."

Turning northwards, leaving the town, and walking along the shore, we soon reach a point opposite to a cliff a portion of the face of which has an orange red colour. This is the section of the Red Crag so well known to collectors as a rich mine of fossils. Approaching the cliff more closely we find the Crag to be, not as its name would seem to imply, a rough hard rock, but a mass of loose comminuted shells with gravel and sand, easily disintegrated and affording very slight resistance to wearing agencies, whether sub-aerial or marine. Even the operations of the fossil collector, if not carefully conducted, may bring down large masses of material, and so destroy some of the land above. The proprietor of the cliff had courteously granted permission to the party to examine the section and collect fossils, a privilege which was taken full advantage of, and in a little time a large number of specimens of the usual species were obtained by Members.

The London Clay forms the base of the cliff, and immediately underlies the Red Crag, which is seen forming the middle of the section. Overlying the Red Crag occur beds of the Chillesford Series, and these again are capped by the "Middle Glacial" of Mr. Searles V. Wood, which forms the top of the cliff, at an elevation of about 50 feet above the sea level. The Red Crag generally varies from three to twenty feet in thickness, and is characterised by a remarkable oblique bedded structure, especially

of the Lingula Flags. The Longmynds range, running for several miles, bounds the view to the east, and this lofty ridge had now to be crossed. The intervening valley affords several sections, at one of which what Murchison considered to be the junction of the Cambrian and Silurian is visible. Near the summit of the Longmynds a very fine exposure of Cambrian conglomerates occurs, and further to the east the edges of the vertical green and purple shales and slates are seen beneath the feet as the mountain road is traversed. On the eastern side of the range the rocks are well exposed and the indenting ravines numerous and picturesque. Caer Caradoc stands boldly out at a little distance to the north-east, with the Wenlock and Aymestry Limestone ridges beyond, and bounding a valley of great beauty and extent, terminated northwards by the volcano-like cone of the Wrekin, at the base of which the Severn flows through a deep gorge.

The morning of the concluding day, Saturday, was given to an examination of the Upper Ludlow Rocks, the Bone-bed and the "Downton Sandstone," in the neighbourhood of Norton Camp and Onibury, and the week's proceedings concluded with a visit to Stokesay Castle, in which Mr. James Parker, F.G.S., gave an interesting account of the curious old pile. Votes of thanks were then most warmly accorded to the Rev. Mr. La Touche and Professor Morris, for their able conduct of the proceedings, which had been attended with marked success.

The extremely interesting character of the district visited, the varied beauty of the country, the fineness of the weather, the kindness and hospitality the Members had received, and the eminence of several of the visitors, combined to make this meeting of the Geologists' Association both very profitable and very enjoyable, and the Members took their departure from the Craven Arms Station congratulating each other on their very agreeable and instructive visit to Shropshire.

ORDINARY MEETING, NOVEMBER 1ST, 1872.

The Rev. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Opening Address of the President of the Botanical Society of Edinburgh, with List of Provincial Societies of Great Britain and Ireland," from SIR WALTER ELLIOT, K.S.I., F.L.S.

"Smithsonian Report for 1870," from the Smithsonian Institution of America.

"Quarterly Journal of the Geological Society," from that Society.

"Annual Report, Abstract of Proceedings, and Catalogue of Library, of the Brighton and Sussex Natural History Society," from that Society.

"The Moss Flora of Sussex," by C. P. SMITH, from the Brighton and Sussex Natural History Society.

"Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire" (1871-2), from that Society.

"Annual Report (1871-2) of the Leeds Philosophical and Literary Society," from that Society.

"Annual Report of the Warwickshire Natural History and Archæological Society" (1871), from that Society.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club" (1871), from that Club.

"Phosphatic and Bone Bed deposits in British Strata," by the Rev. P. B. BRODIE, M.A., F.G.S., from the Author.

"Journal of the London Institution," from that Institution.

"Journal of the Quekett Microscopical Club," from that Club.

"On *Callograptus radicans*, a new Dendroid Graptolite," by JOHN HOPKINSON, F.G.S., F.R.M.S., from the Author.

"Abstract of the Proceedings of the Liverpool Geological Society" (1871-2), from that Society.

"Belfast Naturalists' Field Club's Annual Reports" (1868-1872), from that Club.

The following were elected Members of the Association;—

Alfred Gillett, Esq.; William Muir, Esq.; Henry E. Rawlins,

Esq.; John Bagot Scriven, Esq.; and Amherst Daniel Tyssen, Esq., M.A., B.C.L.

The following Paper was read :—

On the Influence of Geological Reasoning on other Branches of Knowledge.

By Hyde Clarke, Esq., F.S.S., M.A.I., Fellow of the Royal Society of Northern Antiquaries of Copenhagen, &c.

On the installation of the Geologists' Association I was invited to deliver an address, in which were pointed out the several practical objects which the members of the new society might usefully pursue, and thereby accomplish the purpose of the institution. In the course of many years the labours of our colleagues have vindicated the justice of these recommendations by bringing together a mass of valuable facts, and showing what the union of observers can effect, even by means of an organization so unpretending.

Being again invited to address the Association on the opening of a new session, it has occurred to me that it will be less agreeable to dwell on the incidents of our own progress than to deal with some subject of more general influence. This might be found in the growth and history of the science, but such have been often treated, and may be perused in popular works.

There are, however, relations of Geology which have scarcely been considered—those, namely, which, looking beyond its special applications, have reference to its place in the realm of science and its influence on human thought. As a branch of knowledge it is in itself the result of the application of thought, and thus in usual course we are disposed to regard it. This is exemplified in the Influence of Geological Reasoning on other Branches of Science. Inasmuch as Geology is the product of man's influence, so must it react upon him, and, entering on its part in the career of progress, exercise a like function in morals to that which matter once set in motion is destined to perform in the universe, moving and affecting all things, and bringing about other movement and perturbation, even by the cessation of its own action.

It is this direct and indirect action which has given a real vitality to Geology beyond that enjoyed by many other branches of science. Mathematical study does at first sight appear to claim this place, and its value as an instrument of reasoning is great, and

of permanent and constant application, but it does not come home to us with the like power of human sympathy. While Mathematics can claim a direct right to a method of regular reasoning, Geology must be recognised as having fashioned the thought of the age in a general way and in many particulars.

Before the beginning of this century problems of great interest were dealt with wildly. Cosmogony was wild, because it had no facts for its direction, and facts were so handled as to become most assured causes of error. Petrifactions gained admission to museums of curiosities, but there they figured as *lusus naturæ*. The accumulation of these showed orders of shells and of plants, but they taught no lesson, and stood as an impediment to research and a hinderance to knowledge. Fossil shells were accounted for by every assignable cause except what truth could determine; they were even supposed to have been placed on mountain tops by the impossible agency of hundreds of pilgrims.

Without entering upon the details of the mode by which a just system was arrived at, it may be remarked that whereas in other cases one man did so much, that mental philosophy was so far indebted to Bacon and that modern astronomy was relatively created by Newton, the science of the earth has been built up by many individuals, to no one of whom can like pre-eminence be assigned. Geology did not pause, for it enlisted a multitude of labourers, and particularly the humblest. There was no waiting for some one to understand the Principia, nor for making the highest reasoning popular and fashionable, in order that it might afterwards be accepted by scientific men. Geology went on as a science of observation ought.

It is as a science of observation that it has exercised a wholesome effect, because it has been shown that observations of facts, even of a trivial nature, will build up truth, correct conjecture, and afford a useful basis for theory. The process has not, however, been the mere collection of a gigantic museum of insects, or of a large herbarium; because each fact has been discussed and tested, so that interest has never flagged, and, consequently, the co-operation of many, without which little true work can be done in science, has never been wanting.

One of the leading results of the collection of observations was the establishment of stratification, and this of itself may be regarded as having exercised a potent effect on modern thought,

because with it were connected the ideas of succession and progression.

These ideas were not of old so well capable of establishment in any other branch of natural science, for classification in the various kingdoms depended on the assignment of groups and regions, and not on succession ; although cryptogamous plants might be regarded as ruder, they could not be assigned as the precursors of the monocotyledonous or of the dicotyledonous. It was a kind of geographical classification on the plane surface of a Mercator's Chart. Not that theories or suggestions of another kind were wanting, but they were unprovided with support.

Notwithstanding the objections of some writers, reasoning by analogy will always prevail in things human, because, after all, as in things human the mind recognises symmetry, so reasoning by analogies is reasoning by probabilities. The admission of stratification was neither more nor less than the introduction of a canon in moral philosophy, and, as the principle became popularised, so has it been extended to various forms of discussion, even to political articles in a periodical journal.

The palæontological relations of simple mineral stratification tended still more to confirm and develop the doctrine of succession, and laid the foundation for that of survival more distinctly than was comprehended by the preservation of strata from denudation, or other influences. Palæontology, however, has had a direct effect on natural history. The groups of existing animals and plants were anomalous and defective, but, as from time to time fossil members were introduced to complete existing groups, as fossil groups intervened to complete series, and as the ruder beings, recognised in the earlier epochs, were found to precede more highly developed forms, so was a more comprehensive view obtained of the whole connexion of natural history. The higher studies of the natural sciences have certainly been greatly acted upon under these circumstances, and thus the naturalist has been made contributory by an unconscious conscription to the militant expeditions of Geology in the development of new regions of investigation.

A consequence of stratification, mineralogical and palæontological, in extension of succession is the acknowledgment of the passage of greater epochs of time than had been heretofore admissible in history or chronology. Thus the range of the infinite

in space, which was extended by the investigation of the fixed stars, and by the determination of the immense minimum of a parallax, was fortified by that element of the eternal in time, which the existence of animal being, of vegetable growth, or of mineral action on this globe showed to be still beyond the computation of eras, in which myriads of years can be involved, and yet figure in their earliest dates as nothing more than later events of long precedent physical action.

The historian of states and empires, and of the evolution of civilization has been compelled to hesitate and to modify his views even before Geology, in its onward march, had furnished him with implements and other records of man in indisputable association with islands and continents which have perished, and with animals extinct before the world's present surface had been bestowed upon it.

This contemplation of time, on the one hand, affected the narration of those passing events in the precarious career of man, but it also gave evidence of fixity, and of a wonderful and long maintained stability in some of the great manifestations of the constitution of the universe. Thus the eye of the trilobite was brought to bear testimony that in the remotest ages of its existence light must have been made sensible under the same conditions as in this day. Geology, indeed, affords us not solely the history of change, not exclusively that of progression, for it gives incontestable lessons that some incidents are immutable, and thus presents us with another aspect of eternity, too little regarded in our philosophy.

The conceptions of the natural philosopher have not only been extended, but have been made more certain by the contemplation of those great operations of water registered in the pebble, or the grain of shingle, of fire penetrating and upheaving the crust of the globe, of magnetic action to which the lines of mineral formation point. The powers of water are understood to include not only stationary and moving fluids, but long protracted, extensive and enormous effects, produced by glaciers and the various forms of ice. Volcanos had been mapped out on the surface, but the philosopher had to work out new problems of spheres of fire and of incandescent metals, and gases preserving their heat during epochs.

It is such contemplation of facts made known which has prepared the way for a bolder study of the solar system, and of that universe, the sparks of which are alone visible to us as yet. The

conceptions of Herschel, corrected and altered, thus assume definite shape, and we begin to deal with the periodic meteors, unexplained comets, and the photosphere of the sun. So, while other branches of science have illustrated the chemical constitution of this, Geology exemplifies the consistency and antiquity of its formation and its operations.

The elements common to the sun, the planets, and as we are led to believe, the universe, have been wrought up in this globe in succession, not of the generations of man, which we have accepted as antiquity, but during the generations of species.

Geography has now to regard these effects of the past, and to consider the connexion of countries by their strata and their mineral relations. Under such circumstances, too, has the distribution of plants and animals taken place. The geographer must look forward to the mapping-out of the ocean, for we know that what now lies at its bottom and in its lowermost depths, has been what we see rising above its shores and shining as snow-capped peaks. There are a vegetation and an animal life now existing in the sea which are the representatives and continuation of what we have embedded in hard rocks, modified by crystallization, or even affected by fire. The fossil marine fauna and flora are the introduction to what is yet to be discovered. Thus Geology anticipates Geography and Natural History, and gains a forecast of events.

Meteorology, instead of being confined to the registration of the phenomena of the present day, is endowed with a part in the knowledge of vicissitudes and changes of climate, which have left the vestiges of glacial action in the tropics, and planted tropical remains in the polar regions. Thus, while in this temperate land, we can cast our eyes over the green meadows, yet on digging far below we come on fruits and spices, which flourished when the sky was hotter. The adaptation to cold regions of the elephant and other beasts, which we have come to think can live only in the tropics, gives us a new aspect of creation, and opens the way for the idea that in these northernmost parts there may have been black inhabitants, and that a negro skin and woolly hair are not exclusively or necessarily confined to the countries near the line.

As the bonds of restriction of thought by prejudice are loosened, and our grasp gains in freedom, the dreams of the past acquire consistency. Legend takes a nearer approach to history, the old wives' tales which were losing the assent of children, are listened to and gathered up by scholars. Folklore, no longer a miscellaneous

gathering of scraps of superstition, gains interest for its wildest fancies of dragons flying in the air, and of man-eating ogres carrying off their prey to caves. We have seen the dragons which have been hidden under earth for thousands of years, and have found the abodes of the cannibals, and handled their weapons and tools. Thus, in the circle of knowledge, nothing is new under the sun, and in science nothing is childish or trivial, but all hold a just place in the great scheme where the living and the dead succeed each other, and death is the parent of life.

It may be said that an economy of knowledge has been taught to us by Geology, to feel that nothing is waste in matter or in mind, but that it has its timely use. The dung of reptiles, buried for ages, fertilizes our fields, the refuse drift of deserted oceans yields us seams of coal, but by the restoration of past knowledge we no less enrich the mind of man.

The whole teachings of Geology, because they unfold to us the history of the universe, of the globe, and, above all, of mankind, exercise the widest and deepest influence over the vast range of human thought. For the immediate service of Geology there have been enlisted the names of a glorious host of men, whom it is not for us at least to number over, for we daily profit by their work. In the domain of natural history, Geology has given special occupation to Cuvier and Owen. These would have been great without it; they have given a double employment to their discoveries by thus associating them with Geology.

It is in philosophy, including theology, that the effect of geological discussions may most clearly be discovered. Undoubtedly they pervade the whole domain of thought, but they are strongest felt in what are the weightiest subjects. The effect goes beyond the gathering of rocks and fossils, the observation of facts, or their records in scientific journals, because among ourselves more particularly they have become matter of discussion and debate, public and private, and thus have impressed the popular mind. Sharing in their labours with the scientific world, the English on both sides of the Atlantic have more especially promoted the advance of geological studies. These needed in their beginning that freedom of controversy which can alone be enjoyed under free institutions, and which is not compensated by the toleration given to a class of professors, or the indulgence accorded to the creatures of a crown or a court.

The variety of formations in these islands was more favourable

to research than the monotony of the great plains of Europe; and though other countries present the same or more striking phenomena, yet a repressive police or a dominant church did not favour the like expansion of novel and unfavoured ideas.

The study suited Englishmen. The desultory collection of small facts, the dealing with these by piecemeal, agreed with the national instincts. The wider conclusions which arose from these details were forced on conviction after full preparation. More philosophical minds might have waited for the proposition of a complete system, or anticipated it by the promulgation of an embracing theory, which would have been accepted and fought for by a school of students until it was superseded by some other. The present order, as in many things English, has proceeded from the most unsystematic beginnings, being the harvest of what is practical, garnered from the weeds and the chaff. Facts have been tested on the banks of the Thames, the Clyde, and the Shannon, on those of the Mississippi and the St. Lawrence, even on the shores of the Ganges, the Murray, and the Vaal, and wherever wandering men of English blood can wander or settle.

Nowhere but in England and America could the conflict have more usefully taken place with the schools of theological interpretations, which had to conciliate scholastic teaching with the evidences of nature. These evidences were in consequence more severely tested and better established, exposed as they were to the investigation and examination of men compelled to give a reason for their faith, than they would have been by those who reposed their reliance in dogmatic teaching, or even by enthusiasts in Geology, ready to sanctify their own superstitions by an easy belief in what they wished to believe.

Clergy and laity were compelled to study geological facts, and, on the other hand, undoubtedly they had to engage in a harder examination of the Scriptures, and many a one was driven to a closer knowledge of the Hebrew language. Indeed, this department of Oriental learning has been as much promoted by the cause referred to as by any other, not but that a greater activity of the human mind has sharpened all incentives to study.

In theology a breadth has been given to interpretation of historical portions of the Scriptures, which has had a most valuable influence on theology and science. That canon has been confirmed, which, dividing the domain between the two, abandons the prero-

gative of theology over science. Theology must undoubtedly be strengthened by its disembarrassment from the dogmatic teaching, as incontrovertible articles of faith, of what was beset with natural doubts. Many a man must have been brought within the pale of religion in recent days, whose unconquered doubts were condemned by the constituted authority of ignorance and intolerance. On some this salutary lesson must have been enforced—that the bounds of human knowledge are narrow, and its acquirements uncertain.

It happened, in the nature of things, or rather in the nature of the human mind, that the discoveries of Geology affected those inclinations which, in all ages, have swayed belief, and given rise to interminable controversy. Those who accepted a perpetual succession of matter were eager to apply a system which, even in its gestation and its infancy, gave them the elements of succession and progression. Thus the book known as "The Vestiges of Creation" was earnestly perused, and had its day of votaries. The more serious labour of a great student, Charles Darwin, have had a wider effect, because the intellect of Europe awaits each volume of his investigations to decide on acceptance of his doctrines, on confirmation of dissent, or even on suspension of opinion.

These controversies penetrate into the remotest regions, as far as sight can be pushed on by the telescope, or strained in the microscope, and the elements of matter and the beginnings of life are eagerly canvassed. In discovering vitality in its minutest germs and atoms, where the vegetable and the mineral await but transformation to become instinct with thought, Huxley, Bastian, and others, have to confront the most responsible problems, and within the limits of sight—and on the verge of sight—where life is on the point of being born, still to find life a phenomenon intimately connected with matter, and yet beyond it.

All these considerations tend to invest Geology in its highest relations with interest, but they will not authorise us to judge in such controversies. Men of brightest intellect and purest thought will go on, as others have done, to seek in the far past a perfect organisation of matter, which may appear self-sufficing for the economy of the universe. Others, of lower minds, and of lower motives, will follow them in the hope that the sense of responsibility being abolished, the bounds between virtue and vice, good and evil, artificial or divine, as they may deem it, may yet be abolished.

Such is, unfortunately, the inducement to many who peruse geological books, not to acquire truth, but to cultivate doubt. Ethics, however, remain unaffected by physical teaching, and a circle of reasoning brings the experimentalist, whether starting from grounds of simple utility or under the inspiration of moral considerations, to the same result, that what is held to be vice is incompatible with the welfare of mankind.

To the other school, of those who acknowledge evidences of design, Geology offers, in its facts, abundant confirmation, and, by its means, many a man has been strengthened in such convictions. This thing, too, is very certain, that no man, by our studies, has been made less virtuous.

From man in his intellectual aspirations to the science of man in general, is but a step in due course. Ethnology, an earlier science in its traditions, has been greatly favoured by the advance of Geology, and is thereby acquiring the claims of an exact and recognised department of science. Ethnology, in its subject of man, is the nobler science, and has the more distinguished inheritance, but, whatever its development, the mode of reasoning adopted must long be acted upon by that worked out in Geology. We must, for a time, accept strata or epochs of men in the prehistoric and protohistoric periods, we must account for the phenomena of denudation and survival, and even in language, as in the upper strata we recognise the percentage of older fossils, so shall we calculate the persistence of remotest and oldermost roots and words.

In due course we shall expect the reaction of Ethnology on Geology, and perhaps obtain new modes of discovery, or, at all events, of illustration. Whatever may be the immediate results of our studies, we shall nevertheless have this inducement to persevere, that all knowledge is general knowledge, that its relations are with the past as well as the present, that from a flint we may make known the annals of a race of men, or by a fossil point out the extension of unexpected stores of mineral wealth, and that, while no labour of the meanest student is idle or worthless, so there is no fleeting moment of time but may witness the birth of the greatest discovery.

ORDINARY MEETING, DECEMBER 6TH, 1872.

The Rev. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

Geological Map of London and its environs, by R. W. Mylne, F.G.S., from W. H. Leighton, Esq., F.G.S.

"On some new Species of Graptolites from the South of Scotland," by John Hopkinson, Esq., F.G.S., F.R.M.S., from the Author.

"Quarterly Journal of the Geological Society," from that Society.

"Abstract of Proceedings of the Geological Society," from that Society.

"List of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

The following were elected Members of the Association:—

John Dovaston, Esq.; William Holmes, Esq.; Alexander Irving, Esq., B.A.; George Maw, Esq., F.L.S., F.G.S.; William V. Murray, Esq., F.R.G.S., M.R.I.; Miss E. J. Shields; and Arthur T. Walmisley, Esq.

The following Papers were read:—

1. ON COAL SEAMS IN THE PERMIAN, AT IFTON, SHROPSHIRE.

By D. C. DAVIES, ESQ., F.G.S.

Immediately above the Coal Measures on the North Wales Border, occurs a succession of red, brown, and yellow sandstones and marls. A detailed account of these is given in the sections 1, 4, and 7, which accompany this paper. From these it will be seen that the thickness of the whole series at Hafod-y-bwch, on the north, is 420 feet. At Newbridge, four miles south of Hafod, an admirable section is exhibited along the banks of the River Dee, the thickness of which is 330 feet, or thereabouts. At Ifton, three miles more to the south, the thickness, as ascertained by levelling, is the same. This is shown on the general section No. 4. At Sweeney, a mile and a quarter south of the town of Oswestry, we have another section, in which the thickness has decreased to 306ft.

These beds have a general dip to the E. at Haford, S.E. at Newbridge and Ifton, and E.N.E. at Sweeney, following generally

the inclination and direction of the dip of the underlying Coal Measures, with which they are thus far in accord.

If, however, we follow these beds along the lines of their strike, we find that between Hafod-y-bwch on the north, and Sweeney on the south, they cover the edges of about 740 feet of strata, which are present at the former, but absent at the latter place. From this point, if we follow them, we shall find them reaching over the Coal Measures and resting, first upon the Millstone Grit of Sweeney Mountain, and then upon the Carboniferous Limestone at Llynclys and Crickheath, where they are mapped as Millstone Grit. They here dip under the alluvium of the valleys of the Vyrniew and Severn, but they rise to the surface on the other side at the western termination of what is called the Shrewsbury coal-field, near Alberbury. We may trace them from thence to Shrewsbury, and see them resting alike upon the Coal Measures, Silurians, and Cambrians; and following their folds into East Shropshire and Staffordshire, gain here and there glimpses of their unconformability to the underlying Coal Measures. The prevailing redness of their colour distinguishes them from all subjacent strata. There is also, as will be seen, an absence of any continuous coal bed throughout a longer succession of strata than occurs in the Coal Measures proper, although a thin seam of a few inches here and there marks the continuation upwards of the Carboniferous flora.

It is not to be wondered at, therefore, that these beds have been considered by the members of the Geological Survey as marking a distinct era from the Coal Measures, one marked especially by decidedly different mineralogical conditions, hence the beds have been coloured and named of Permian age.

It is, however, to the strata overlying these red sandstones and clays, that I wish to direct special attention in this paper. The district in which these occur is that which lies in the north-west corner of Shropshire, lying between the Gobowen Station of the Great Western Railway on the south and the River Dee on the north, as well as the portion of Denbighshire immediately north of the Dee, including the Park of Wynnstay, the seat of Sir Watkin Williams Wynn, Bart., M.P., and extending to the country between Ruabon and Wrexham, lying east of the road between those two places.

It is in the vicinity of Ifton, which constitutes a flat table land bounded on the north by the River Dee and on the west by the

River Ceiriog, with its little tributary the Morlas, that the beds to be described offer the best opportunities for their study, and it is with that locality we will begin.

Section 8 illustrates the structure of the country and strata lying between Brynkynallt colliery on the west, and Ifton colliery on the east. The section follows the dip of the strata N.W. to S.E. This and Section 6 are the result of many researches in connection with the collieries mentioned, and traverses of the ravines (which run into the brook Morlas, where fine sections of the outcrops of the strata are to be seen), which I have made in company with my friend Captain Henderson, F.G.S., of Plasgwyn.

The continuation of the Coal Measures proper under the Permian is assumed from analagous cases in the neighbourhood.

By a reference to Section 6, it will be seen that above the red beds there comes a succession of clays and shales, a coal seam, and green and purple grey sandstones, at the top of which we reach a seam of coal 1ft. 6in. to 1ft. 8in. in thickness. Above this there is another series of shales, clays, and sandstones 45ft. thick. At this point we reach a bed of clay, to which I shall presently direct particular attention, inasmuch as it contains numerous round or nodular lumps of limestone, many of which have cavities in the interior. At the top of this clay we reach the principal coal of the district, which is however not one unbroken bed, but is made up as follows:—

Top.	Coal	... ...	2ft. 6in.
	Dirt	... ...	7in.
	Coal	... ...	6in.
	Fire Clay	... ...	1ft. 0in.
	Coal	... ...	1ft. 3in.
	Fire Clay	... ...	6in.
	Coal	... ...	6in.
			6ft. 8in.

The fire clay, 1 foot thick, is remarkable as being full of pla remains, *Pecopteris lonchitis* is the prevailing form, but besides th we find *Pecopteris* of other species, as well as *Sphenopter Walchia*, *Asterophyllites*, *Equisetites*, *Annularia*, *Calamites* a *Lepidodendron*. In the coal itself we frequently obtain *Ca modendron commune*, as described by Mr. Binney.* I h not yet obtained, either from the coals or clays, any specimens

* See "Plants of the Coal Measures," Palæontographical Society's Volume for 18

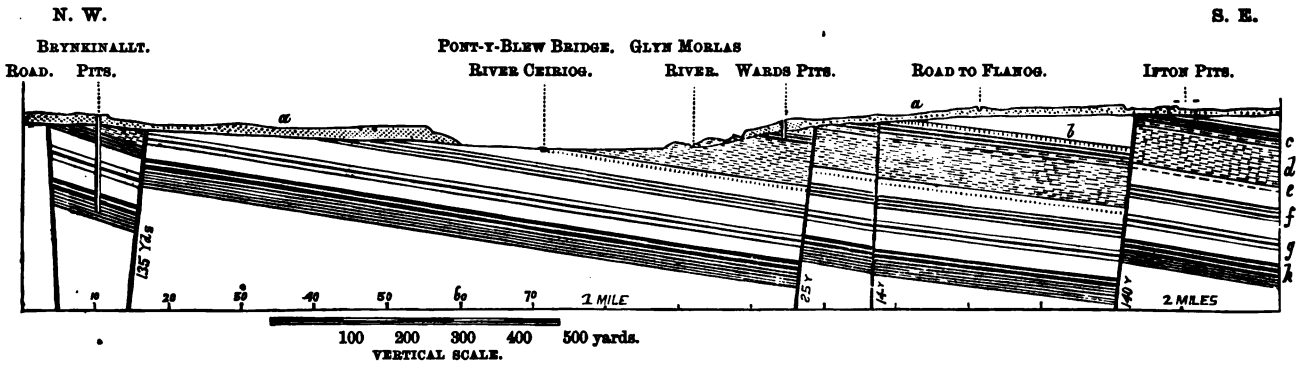
Stigmaria or *Sigilaria*, which are so common in the Coal Measures proper. I will not venture to say that these plant and root remains are not to be found, but the fact remains that during a series of many visits I have not seen a specimen.

On this coal there lies a blue and brown shale, and above this we come to a mass of greenish white and grey sandstone rock, locally known as the Coed-yr-allt rock, so called because it forms the bold wooded escarpment of that name which overhangs the picturesque defile of the Dee. This rock, with its partings of shale, varies in thickness from 30 to 60ft., and it seems to have a general decrease in thickness in its course south-east. It makes a very tractable building stone, but it has not been used much away from the neighbourhood, because of its inaccessibility. It is capped by a soft red rock, and above this we have in places—as shewn in the section of Flanog new pit, Section 3—a seam of coal 1ft. 6in. thick. This coal is of good quality, but exceedingly tender. Above this coal there lie shales and marls with bands of hard rock, with calcareous veins. At this point we reach the gravel and Boulder Clay which covers the country, so that we have no means of ascertaining what strata, if any, lie between these uppermost beds of the sections, and the Bunter Sandstone which comes to the surface some distance east of Ifton colliery.

The middle coal bed has been worked for many years. Its out-crop is to be traced under the Coed-yr-allt rock and along the steep eastern banks of the Ceiriog and Morlas, as shown upon the map of the Geological Survey. It seems to have been originally worked from the out-crop by means of an adit. Afterwards the late Mr. Ward sank shafts through the overlying rock, as shewn in the Section 8. The Messrs. Davies of several generations have also extensively worked it in the north-eastern corner of Ifton district. Later it has been worked by means of the Ifton shafts; and the coal has also been reached at a depth of 25 yards at Wigginton, south-east of the village of Saint Martin's. The coal has not been worked south of this place, but I have no doubt of its continuation southward under Rhos-y-gadfa and Ebnall to the point where this highland slopes down into the valley of the Perry, half a mile north of Gobowen Station.

If now we turn our faces northward we shall find these same Coal Measures covering the red beds on the north side of the River Dee. They occupy the rising ground immediately to the east

SECTION (No. 8) THROUGH BRYN-KINALLT PITS, PONT-Y-BLEW BRIDGE, AND IFTON PITS.



a Boulder Clay and gravel.
b Coed-yr-allt rock.
c Ifton Coal.
d Red marls and rock.
e Porous greenish sandstone.
f Newbridge shales and coals.
g Dirty Coal.
h Yard and half, Main, and other coal seams.

Datum line 1645. 23 feet below stone in parapet of Pont-y-blew Bridge.

of the village of Ruabon. At Pentreclawdd, a farmhouse one and a-half miles north-east of Ruabon, they seem to have been worked a little. A quarry and a record of a shaft sunk at Pentreclawdd, and the result of a boring made at Morton a little further north still, enable me to give Section 2, which will be found in its main features to correspond to the Ifton section. Immediately north of Morton we descend abruptly to the red beds which here come to the surface, the overlying Coal Measures having apparently been denuded eastward. Traces of them, however, reappear in the sides of the brook near King's Mills, east of the town of Wrexham, and then the deposit of Drift, which is very thick, hides them from our view in that direction.

Thirteen miles W.N.W. of Wrexham we reach the head of the Vale of Clwyd, which is, as is generally known, filled up with beds of the New Red Sandstone.

A few years since, however, Mr. George Maw, F.G.S., obtained from shales which come up from under the edge of the Bunter Sandstone the following plants:—*Ulmannia*, *Walchia*, *Pecopteris* of several species, and *Calamites arundinaceous*, all of which Mr. Etheridge thought had a decidedly Permian aspect. From the resemblance of these plants to those found at Ifton, as well as from the general agreement of their position, I do not doubt the identity of the beds at the two places.

I may also mention that during the construction of the Vale of Clwyd Railway, some years since, between Denbigh and Rhyl, a bed of impure coal, cropping up from under the Bunter Sandstone, was cut through. I think, therefore, we may safely assume, concerning the extent of the strata of the Ifton coal seams—1st, a thinning-out due south, as indicated by sinkings at Wigginton, and their disappearance in a southerly direction; 2nd, that while they may now exist in full force due east under the Bunter Sandstone, they once had a much greater extension to the west, as indicated by the discoveries in the Vale of Clwyd; 3rd, the coal seam struck in the northern portion of that vale, and the similarity of some sections north of the City of Manchester to portions of the Ifton sections, point to a continuance of the Ifton beds from Wrexham northward under the New Red Sandstone plain of Cheshire, and their emergence in an altered form in the Permian beds overlying the Lancashire Coal Field.

We may now proceed to correlate the beds I have been describing

with the Permian rocks elsewhere, especially with the typical British Permian district in the north of England.

I have already shewn how the red beds at the base of the Ifton sections continue south and sweep around to the east, forming for the most part an inner fringe of the sinuous belt of the connected coal fields of Shropshire and Stafford; but sometimes, as we have seen, overstepping all such bounds, and covering indiscriminately all manner of rocks down to the Cambrian. There can, I think, be little doubt that they are the equivalents of the Rothtodtliegende of the continent of Europe, and also of that mass of red sandstone and marls which have been described by the late Sir R. I. Murchison and Professor Harkness as covering the Coal Measures of the north-west of England. See Quart. Journ. Geol. Soc., vol. xx., p. 144.

In that region, as well as in the north-east of England, as described by Professor Sedgwick,* these red sandstones and shales are succeeded by magnesian limestone, magnesian conglomerates, and sandy beds, more or less calcareous. This corresponds to the arrangement of the beds at Alberbury, fifteen miles south of Ifton, where the red beds are succeeded by a calcareous conglomerate which has been worked for the lime it contains.

At Ifton, too, although we have the addition of the coal seams, we get, as we have seen, conglomerate beds of clay and limestone, and sandstone beds, with calcareous nodules and spar. I would here also direct especial attention to the bed under the principal Ifton Coal Seams to which I referred before. It contains rounded lumps of limestone with cavities in the interior. Sir Roderick Murchison and Professor Harkness—in the paper already referred to—describe a similar bed as occurring near Brough and Kirby Stephen at the top of the lower Permian sandstones. This is their description:—"Here the Magnesian Limestone fragments present themselves hollow in the interior, possessing the character of potato-stones" (*ibid.*, p. 150). A similar bed in a similar position in two localities far apart. The same author, also, in describing the beds overlying the red sandstones and shales in Hilton Beck indicate in the following remarks a further resemblance both palæontologically and stratigraphically between the beds of the north and those of Ifton:—"The basement-beds of the

* Transac. Geol. Soc., Second Series, vol. iv., p. 383.

Middle Permian rocks, as seen in Hilton Beck, are finely exposed at Ash Bank, and consist of cream-coloured shaly sandstones with thin partings of grey shale, and occasionally a narrow band of impure sandy limestone which weathers brown. These beds contain a considerable number of vegetable remains, among which Mr. Etheridge has recognised the following :—*Sphenopteris Naumanni*, *S. dichotoma*, *Alethopteris Goepperti*, *Ullmania selaginoides*, *U. Bronnii*, *Odontopteris* sp. (?), *Sphenopteris* sp. (?), and *Cardiocarpon triangulare*. Portions of coniferous wood also occur" (ibid., p. 154). The ullmaniæ, we are further told, " are common at the base of the Magnesian Limestone of Midderidge, in Durham, and the other forms occur, along with *Ullmania*, in the Kupferschiefer of Germany." We have already seen how *Ullmania* was found in the Permian shales of the Vale of Clwyd, and it is easy to see the general resemblance of the plants of all the localities named with those of the Ifton beds. There cannot, therefore, as it appears to me, be any doubt that the Ifton strata, from the summit of the red ground upwards, are the equivalents of the middle and principal member of the Permian group of the North. That while they have their own special characteristic, namely, a flora abundant enough to produce the coal seams described, they also have, in their sandstones, shales, conglomerates, and calcareous sandstones, sufficient family likeness to the magnesian limestones, conglomerates, and breccias, which elsewhere occupy the same stratigraphical position immediately above the red sandstones and marls. We have here, therefore, the whole series of Permian beds, with the exception of that thin uppermost member which forms a junction with the overlying Bunter Sandstone.

There are several thoughts in connection with the strata under consideration to which I would briefly, in conclusion, direct your attention.

The first inference would be more properly drawn from the upper Coal Measures, which underlie the red beds at Hafod-y-bwch and Pentreclawdd, near Ruabon, but as it will prepare the way for what is to follow, I may be allowed to consider it here.

It is generally understood that there is a considerable break or gap, denoting the lapse of a long period of time, between the Coal Measures and the base of the overlying red Permian beds ; inasmuch as the latter often lie unconformably upon the eroded and worn surfaces of the former, and have not unfrequently a different strike and dip.

Still we know there must be, somewhere or other, portions at least of the memorials of that period—some traces of strata which would be deposited in some parts of a widely extended area. Where are these to be found? Have we any trace of them in the district we have been considering? I think we have. We are able to assign the coal beds of the Shrewsbury coal-field their true position in relation to those of The Drill and Sweeney, south of Oswestry. We are also able to correlate the beds of the Coalbrook Dale and Shifnal district with those of the Shrewsbury and Staffordshire coal-fields. A few yards added to the top of the Coal Measures in the Sweeney section would comprise the uppermost beds of all those coal-fields, upon whose worn edges the red beds of the Permian repose. But, passing from Drill and Sweeney northward by Ifton to Hafod-y-bwch, we find, as I have before said, a succession of beds interposed, which, when we reach the latter place, have a thickness of about 740 feet. In plain words, there is a gap between the summit of the Coal Measures and the base of the Permian of 740 feet at Drill and Sweeney, which is filled up at Hafod-y-bwch, twelve miles to the north, with sandstones, shales, and coal.

He has need to be a good reckoner who computes geological time, so I will not venture to say how long it would take for the deposition of these 740 feet of strata. But you will at once see how, during that long period, as it must have been, there was large scope for disturbances of strata, for slow atmospheric waste, for erosion by rivers, and floods, and tides; and for the play of all the causes which gave the worn and wasted look to the Coal Measures over a large area, and which produced the frequent unconformability of the Permian strata.

It is difficult to say of any section of strata, "Here we have a complete series without a break," and I am not going to say as much of the Upper Coal Measures near Ruabon; but the fact remains that here we have 740 feet of strata, a portion of which is shown in the Newbridge section (4), which were quietly deposited, while over a large portion of country not only was either no such deposition going on, or strata only were deposited to be ruthlessly washed away and destroyed. The similarity of dip in the Coal Measures and Permian at Ifton and Ruabon indicate a continuity of deposition, and at least some close degree of connection between the two groups.

Further, it is generally held that with this supposed break in the order of strata, there is a marked change in the nature and character of the stream of life on the globe. But just as we have seen that in the district described there is a stratigraphical connection between the two geological formations, so it will be seen that it is equally true that into the age of the Magnesian Limestone, with its new forms of life, there was a passing upward of a large portion of the Carboniferous flora, which long flourished where the conditions were favourable, amidst the new type of surrounding life. We thus infer, that groups of strata are not divided by sharp lines and well-defined boundaries, but, that they are rather dovetailed into each other. The new commencing earlier here, and the old ever rising up into and lingering in the new ; so that while the individual forms of life change in character and proportion of numbers, the stream of life flows on for ever.

The beds under consideration have a bearing also upon the theory of a glacial climate having prevailed during the Permian epoch.

The indications of such a climate were observed by Professor Ramsay in the conglomerates above the red beds at Alberbury, some fifteen miles south of Ifton. At the latter place, however, we have, as we have seen, evidences of the existence of a luxuriant tropical flora ranging throughout the deposition of 250 feet of strata which occupy the horizon of the conglomerate, and to which some of the beds bear a resemblance. It will at once be seen that the two conditions of climate could not have existed at the same time within so limited an area, and unless the supposed glacial conglomerate at Alberbury can be taken higher up in the series—which I do not think it can—its origin must be assigned to some other cause than that of glacial action.

I would also observe, in conclusion, that in any future mapping of the geological features of the country, the boundary lines between the Permian and the Coal Measures must be considerably altered—that is, if the red beds are retained as the base of the Permian, as I think they should. North of Ruabon they must be extended westward to the high road leading to Wrexham. From Ifton they must be continued westward to Brynkynallt, as shown in Section 8. South of Oswestry they must be produced in the same direction, and continued southwards to Llynclys, Morton, and Crickheath; with minor alterations between. Explorations and

mining operations since the present maps were issued have furnished information on this point, which was wanting before, and have rendered the changes indicated necessary.

Since the above paper was read, I have twice been over the district in question with Mr. J. Dickenson, F.G.S., Inspector of Mines, who by the occurrence of Coal Measures above the "red ground," which he, in common with others, had taken to belong to Permian strata, has been led to include the whole series in the Coal Measures proper. The red beds correspond, in his estimation, to similar beds which divide the Upper from the Lower Coal Measures in North Staffordshire. If this be so, then the greater part of the red beds of the kingdom which hitherto have been mapped as Permian must now be included in the Coal Measures. There still remains the great thinning out of beds, which I have described as existing between the base of the red ground and the Coal Measures from Hafod-y-bwch to Sweeney and Drill, and which may be gradually traced nearly all the way between the extreme points. However, I prefer that the Paper should appear as it was originally read. It will possibly excite discussion out of which the true position of the beds described will be elucidated. Much depends upon the identity of the "red beds" of Ifton and of Sweeney, and that identity will be ascertained by colliery operations in which I am now engaged.

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2. On a Well Section at Finchley.

By Caleb Evans, Esq., F.G.S.

The various deep wells that have been constructed in and around the metropolis enable the Geologist to form a general idea of the stratification of the London Tertiary District, although there are many minor details which, without clear and continuous sections, cannot be determined. The valuable work of Mr. Whitaker, "On the Geology of the London Basin," in which 488 of these well sections more or less perfect have been published, has added considerably to our knowledge on this subject. The majority of these well sections have been recorded from within or in the immediate neighbourhood of the Metropolis, and there are many

parts of the environs of London at a considerable distance from any of these published sections, and any new sections formed in these intermediate areas are, therefore, both interesting to the Geologist and valuable for practical purposes, more especially as the deposits, both above and below the London Clay, in North Middlesex vary greatly in mineral character.

In the summer of the present year (1872), the East Barnet Gas and Water Company commenced the construction of a deep well at the north end of Finchley, but I was not aware of this undertaking until it had been some time in progress, and I was, therefore, unable myself to note the higher deposits passed through, and I have only been able occasionally to watch the operations. Under these circumstances when the borers had penetrated to the Chalk, I applied to the Water Company for information, and through the kindness of J. Stokoe, Esq., the Resident Engineer, I have been furnished with the following details of the strata passed through in this well.

THE FINCHLEY NEW WATER WORKS.
(WELL EIGHT FEET DIAMETER.)

	Feet.
1.—Clay	20
2.—Sand with Water	4
3.—Blue Clay with Chalk Flints	6
4.—Dark Clay, and Black Pebbles, and Flints	12
5.—Sand and Gravel, with Water	13
6.—Blue Clay	169
7.—Clay-stones with Shells	2
8.—Coloured Clay	21
9.—Gravel with Water	3
10.—Mottled Clay	2
11.—Black Pebbles with a little Water	25
12.—Dark Sand with a little Water	7
Flints and Chalk.	

The well was sunk to bed No. 9, and from that depth a boring was continued to the Chalk, which at the end of October last had been penetrated to a depth of 90 feet, and the boring was to be continued to a greater depth.*

The level of the surface of the country in the neighbourhood of this well is about 290 feet above the Ordnance Datum, the well

* I have learnt from a friend that on the 4th Dec., 1872, the boring had reached 500 feet from the surface, and the work was still in progress in Oct., 1873, at which time a depth of above 600 feet had been reached.

having been sunk from the top of the plateau that extends from Finchley to Whetstone. Of the strata traversed by this well section the five highest beds belong to the deposits of the Glacial Epoch, which occupy the upper portion of the Finchley plateau. They differ, however, slightly in character from the deposits exposed in the section by the Finchley Railway Station, which were described by Mr. H. Walker, F.G.S., in his paper, read before this Association in December of last year.* The variable character of deposits derived from the action of glaciers and icebergs is seen in the sections around Finchley, Hendon, and Whetstone, the materials appearing in some spots to have been derived from the Bagshot Sand and London Clay and in other cases from more distant formations.

The Clay (No. 1), extending from the surface to a depth of 20 feet, is greenish brown in colour, at least in the upper part, and it resembles in appearance the clay which was exposed at East End, Finchley, at the time when the railway cuttings were formed at that spot. A similar clay is seen in the Manor brickfields, where it contains drifted fossils and blocks.

The bed of Sand (No. 2) is doubtfully represented in the railway sections, but sands occur at Hendon and gravel at Whetstone considerably above the base of the Glacial deposits.

The beds (Nos. 3 and 4) described as "Blue Clay with Chalk Flints" and "Dark Clay with Black Pebbles and Flints" represent probably the clays with masses of chalk seen in the lower part of the section at the Finchley Railway Station and, although no mention is made by Mr. Stokoe of chalk as one of the materials contained in these clays at the well section, I think it highly probable that that rock is present in addition to the "Chalk Flints" and pebbles.

The bed of Sand and Gravel (No. 5) is the lowest of the Glacial deposits in the neighbourhood of Finchley and is of considerable importance, as it forms the principal water-bearing deposit of the district around Hendon, Finchley, and Whetstone, and the springs which issue from the lower portion of this bed serve as useful indications of the junction of the Glacial deposits with the London Clay below.

The stratum (No. 6), described as "Blue Clay," presents for the

* Proc. Geol. Assoc., vol. ii., p. 289.

greater portion of the thickness of 169 feet the ordinary characters of the London Clay, consisting of a stiff clay with bands of septaria. The fact that this clay is not more than 169 feet thick at Finchley indicates that the lower portion only of the deposit now there remains, and that more than 200 feet of the stratum had been removed by denudation prior to the deposition of the Glacial beds.

Fossils do not appear to be very numerous in the London Clay of this well, but I was informed by one of the workmen that at a depth of about 130 feet from the surface there was a layer of the clay containing many fragments of *Pentacrinus*, a specimen of which he showed to me. This fact is of considerable interest, since the depth above mentioned would place this layer at about 100 feet from the bottom of the London Clay, and it is at about the same position in the clay that this fossil occurs so abundantly at Gatti's Ice Well in the Caledonian Road, and at the Gas Works at Battersea as described by Mr. Coombs.*

Although no change of character is recorded by Mr. Stokoe throughout the 169 feet of "Blue Clay," the lower portion of the bed (in which the excavation was proceeding at the time of my first visit) becomes coarser and more mixed with green sand, and this portion also contained many vegetable fragments and slight traces of wood bored by the *Teredo*, and occasionally isolated pebbles.

The most remarkable deposit in this portion of the section is a band of compact lignite, about one inch thick. Although no animal remains have been met with in this sandy clay, there is little, if any, indication of freshwater conditions, the stiff clay above and the stone below being both clearly marine; moreover, this lignite shows no evidence of having been formed from drifted wood, and it is difficult to imagine under what conditions this layer could have been deposited.

In most of the sections in the neighbourhood of London, in which the lower part of the London Clay is exposed, a thin group of beds is present, which has been termed by Mr. Prestwich "The Basement Bed of the London Clay." In most localities the principal stratum of the Basement Bed consists of a layer of rounded flint pebbles, and in these instances the bed is devoid of organic remains, with the exception of the teeth of *Lamna;* but in other spots,

* Proc. Geol. Assoc., vol iii., p. 33.

where the pebbles are not so abundant, some of the layers are highly fossiliferous. This is especially the case in the neighbourhood of Reading, and at Hedgerley, near Slough.

A group of fossils similar to those met with at Reading and Hedgerley, is also recorded from Batchworth Heath south of Rickmansworth, from Bushey near Watford and from the well at the Lower Heath, Hampstead.

The bed (No. 7) of "Clay-stones with Shells" is evidently the representative of the Basement Bed, in which group the sandy clay immediately above and the band of lignite should perhaps also be included.

The stone varies slightly in mineral character, some portions approaching to a crystalline limestone, and others consisting of an argillaceous limestone. Occasionally the stone resembles septaria and is traversed by cracks filled with veinstone.

The fossils are chiefly found in one or more bands in the form of sharply defined casts and impressions, which are frequently sufficiently perfect to admit of identification. The most abundant shell is a *Cyprina* closely resembling the *C. planata* of the London Clay. This species is not recorded by Mr. Whitaker from the Basement Bed, but an undescribed species of this genus and also *C. Morrisii* are mentioned from several localities in the London district. *C. planata* is also very abundant in the Bognor Beds of the Isle of Wight and at Portsmouth. It is also a very common fossil in the Lower Tertiary beds of East Kent.

Another common fossil of this stratum at Finchley is the so-called *Panopæa intermedia* (which in some of its characters approaches to the extinct genus *Myacites*). This shell is but rarely found in the London Clay in the neighbourhood of the metropolis, but is more abundant in Berkshire, Hampshire, and at Bognor, and it is present in many of the sections of the Basement Bed.

Another species, abundant in the Finchley shell-rock, *Cardium Laytoni*, prevails in the Lower Tertiaries, but has not been obtained from the London Clay. It is common in the Basement Bed at Hedgerley. *Aporrhais Sowerbyi*, another Finchley fossil, is a shell also characteristic of the Basement Bed. *Natica labellata*, a fossil which ranges throughout the whole of the Eocene strata, is also common, and a fragmentary specimen perhaps indicates the presence of *Natica subdepressa*.

In addition to the above the Finchley stone contains two or

three species of *Cytherea*, some probably undescribed, also a shell resembling a *Sanguinolaria* or *Glycimeris*, and some small casts of univalves. *Ditrupa plana*, a fossil which is present in great numbers at Hedgerley and Reading, has not been found at Finchley.

The greater number of the shells of the Lamellibranchiata occur as single valves, and the animals did not perhaps live exactly at the spot where their remains are now found, but as the impressions are in general sharp and unworn, the shells had probably not been drifted from any great distance. In a few instances *Panopæa* occurred between the layers of shells in an oblique position approaching to that in which the animal was placed when living. The whole fauna of this shell bed indicates a depth of about 70 fathoms, and a temperate climate.

The strata, that intervene in the Finchley Well between the fossiliferous Basement Bed and the Chalk, are the representatives of the Woolwich and Reading Series and perhaps of the Thanet Sands. The Woolwich and Reading Series is represented in Hampshire by a thick deposit of red mottled clay, and in the neighbourhood of Reading, and generally to the west and north of London, by mottled clay associated with layers of sand and pebbles, while in West Kent estuarine and freshwater conditions prevailed, and in East Kent the series is represented by marine sands.* The Thanet Beds (fossiliferous in East Kent) form in West Kent thick beds of sand, which thin out rapidly to the west and north.

A comparison of the Finchley section with the published well sections, nearest to that spot, shows that the bed (No. 8) of coloured clay extends over a considerable area, but appears to thin out to the north, since it is 21 feet thick at Finchley and about the same thickness at Colney Hatch, but the corresponding bed at New Barnet to the northward is 16 feet thick, and at Hampstead to the south it is 40 feet in thickness

The bed (No. 11) of flint pebbles in sand is 25 feet thick ; this is an unusual thickness for this pebble bed in North Middlesex, as is shown by other well sections. At Colney Hatch the bed of pebbles is 6 feet thick, and at The Hyde near Hendon not more than 2 feet thick, with 9 feet of mottled clay above and 12 feet of mottled clay below it. At Harrow 5 feet of pebbles occur beneath 17 feet of mottled clay. At Hampstead the presence of pebble

* See Proc. Geol. Assoc., vol. ii., p. 67.

beds is doubtful, but at Barnet, as at Finchley, there are two pebble beds separated by a thin band of mottled clay, but at the former place the higher bed is only 1 foot, and the lower 7 feet thick.

The great thickness of the pebbles at Finchley appears to have been formed at the expense of the sand below (the doubtful representative of the Thanet Sands), which is there 7 feet thick, while at Colney Hatch it is 25 feet, at The Hyde 11 feet, and at New Barnet 13 feet in thickness.

This sand (No. 12) is the lowest of the Tertiary strata at Finchley, but I was informed by one of the well-sinkers that a bed of flints about two feet thick intervened between it and the Chalk; this is probably the well-known deposit of "Green-coated Flints."

With regard to the Chalk little could be learnt, owing to the wet and disintegrated condition in which the material was brought to the surface. Indications were seen of several bands of flint nodules and of a band of tabular flints.

The foregoing deposits do not present any features of great novelty; but I have thought that the details of a Tertiary well-section at a considerable distance from any already published are of sufficient interest to be recorded in the "Proceedings of the Geologists' Association."

ORDINARY MEETING, JANUARY 3RD, 1873.

The REV. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"The Agricultural Geology of the Weald," by W. Topley, F.G.S., from the Author.

"Geology of the Straits of Dover," by W. Topley, F.G.S., from the Author.

"The comparative Agriculture of England and Wales," by W. Topley, F.G.S., from the Author.

"The Nomenclature of the Foraminifera," by W. K. Parker, F.R.S., and Prof. T. Rupert Jones, F.R.S., from the Authors.

"Abstract of the Proceedings of the Geological Society," from that Society.

Weather Maps issued by the War Department, United States, from the United States Meteorological Department.

The following were elected Members of the Association :—

The Rev. Ebenezer Davies; Henry Hicks, Esq., M.R.C.S., F.G.S.; C. F. Hancock, Esq., B.A., M.R.I.; and Walter E. Koch, Esq., F.G.S.

The following Paper was read :—

ON THE CAMBRIAN AND SILURIAN ROCKS OF RAMSEY ISLAND, ST. DAVID'S.

By HENRY HICKS, Esq., F.G.S.

Ramsey Island is situated on the West Coast of Pembrokeshire, and at the nearest spot is about three quarters of a mile distant from the main land. It is about two miles long, and from half to three quarters of a mile wide. It extends along the coast in a line almost due north and south. The southern half consists of several masses of intrusive greenstone, or quartz porphyry, metamorphic rocks, and some bands of black shale. The northern half consists of almost vertical strata of sandstones and slates, with one hill of greenstone on the west side, and a few intrusive veins. A section across the north end, beginning on the east side or that facing the main land, shows the following rocks in succession :—

(1.) LINGULA FLAGS.—A series of hard siliceous sandstones with grey flaky slate, about 600 feet in thickness, and containing *Lingulella Davisii* in great abundance, but no other fossils save

worm tracks and burrows, and some plant-like markings. The series usually attains a much greater thickness than is shown at this spot, and probably is only hidden here in the channel which separates the Island from the main land, where the lower rocks occur. These beds are frequently ripple marked, and show other indications of having been deposited in shallow water. Towards their junction with the next succeeding group, however, they become somewhat finer in character and more slaty, but yet not sufficiently so to yield the fossils common in this portion of the Lingula Flags in North Wales, and in the neighbourhood of Malvern. Evidently these beds at Ramsey Island were deposited in shallower water than the beds in those districts, and the fauna accordingly is more scanty.

Resting conformably on the last mentioned beds, we have the (2.) TREMADOC GROUP, or rather a thick series of beds holding in the succession relatively the same position as the Tremadoc Rocks do in North Wales. These graduate by almost insensible degrees from the Lingula Flags, first as bluish grey flag, and then earthy grey thick bedded rock of a peculiar tough texture.

Towards the upper end, however, they become darker in colour and more slaty. They have a thickness of about 1,000 feet, and fossils are very abundant throughout the whole series. These rocks are also exposed at several other places in the neighbourhood of St. David's, but their junction with the Lingula Flags is nowhere so well seen as in this section. Wherever exposed the beds are invariably rich in fossils, but the cleavage which has affected the beds considerably renders it difficult to obtain very perfect specimens. The species discovered are nearly all new, as also several of the genera. Most of these were described by me recently in a paper read before the Geological Society,* and the fauna is important in showing the earliest lamellibranchs, encrinites, and starfish which have hitherto been discovered in Britain.

In succession to, and resting conformably upon the Tremadoc Rocks, are series of dark slates of about 1,000 feet in thickness. These we have proposed to call by the name (3) LOWER ARENIG, as they are shown to underlie the true Arenig Series, and to form an intermediate group of strata between the latter and the Tremadoc Rocks, as recognised here. In these rocks, during some recent researches carried on by Messrs. Homfray, Lightbody, Hopkinson,

* Quart. Journ. Geol. Soc., vol. xxix., p. 39.

Kirshaw, and myself, a very rich fauna of graptolites was discovered; and Mr. Hopkinson's thorough knowledge of these forms of ancient life has enabled him to recognise amongst them about 22 species, and, moreover, to correlate the beds through these with the Quebec Group of Canada. The other fossils discovered in these beds comprise species of *Æglina*, *Ogygia*, *Asaphus*, *Trinucleus*, *Conularia*, &c. Some of these species were described by the late Mr. Salter, but the majority are as yet undescribed. This section is of considerable importance in a stratigraphical point of view, as it exhibits the connection of Silurian with Cambrian strata, and shows that no considerable break can exist between the two formations. It is this section also which makes the geology of Ramsey Island deserving of special consideration, for nowhere perhaps in Britain is the succession of these rocks so clearly shown as they are in this coast section. A fault in the line of bedding has removed the remainder of the series, and the Lingula Flags are brought against the Arenigs unconformably at the west side of the Island.

ANNUAL GENERAL MEETING, FEBRUARY 7TH, 1873.

The Rev. THOMAS WILTSHIRE, M.A., F.G.S., President, in the Chair.

The following Report was read by the Honorary Secretary:—

REPORT OF THE GENERAL COMMITTEE FOR 1872.

The General Committee have again the satisfaction of presenting to the Members of the Geologists' Association a Report recording great prosperity and progress.

The elections of new Members during the past year have been very numerous, and have added to your body several gentlemen well known as good and careful workers in Geological investigation.

Notwithstanding the greatly enlarged expenditure consequent upon extended operations, it will be observed from the Treasurer's Account that the income of the Association has more than correspondingly increased. Your Committee notice with great pleasure that a considerable sum has been received by the sale of publications, since it attests increased attention to the operations of the Association and interest in Geological science. The balance at the close of the year being very considerable, your Committee

have decided upon the investment of the amount of the Life Compositions paid during the past two years.

The Papers presented to the Association, and read during the year 1872, were of more than usual importance, and were contributed, in some instances, by authors of eminence. Relating, as these communications do, to very various subjects and widely different localities, they cannot fail to prove of great educational value.

That which may be called the distinctive feature of the Geologists' Association—the organisation and conduct of educational Excursions or field meetings—formed last year a prominent portion of our proceedings. The greater number of the excursions were largely attended, and were evidently fully appreciated by those Members who shared in their advantages. The concluding excursion, extending over six days, distinguished the season of 1872; and you will be gratified to learn that the week's investigation of the Silurian and Cambrian rocks of Shropshire not only afforded valuable instruction to Members, but was followed by important scientific results. The high scientific character of the Excursions of the Geologists' Association will be at once apparent from the following list of Geological Formations observed and studied during the year 1872:—

POST GLACIAL—Aylesford, Crayford, Erith.
GLACIAL DRIFT—Finchley, Hendon, Watford.
RED CRAG—Walton-on-the-Naze.
BAGSHOT SANDS—Hampstead.
LONDON CLAY (Basement Bed)—Bushey.
WOOLWICH AND READING SERIES—Bromley, Bushey, Sundridge Park.
THANET SANDS—Erith.
CHALK—Chislehurst, Crayford, Erith, Guildford, Watford.
LOWER GREENSAND—Guildford, Maidstone.
GREAT OOLITE—Hampton Down, Bath.
INFERIOR OOLITE—Dundas, Somersetshire.
UPPER LIAS—Dundas.
MIDDLE LIAS—Dundas.
LOWER LIAS—Newbridge Hill, Weston, Twerton.
RHÆTIC SERIES—Newbridge Hill.
UPPER LUDLOW—Downton, Ludlow, Norton, Onibury.
LOWER LUDLOW—Evenhays, Leintwardine, Mocktree, Wigmore.
WENLOCK—Burrington.
LLANDOVERY—Longmynds.
CARADOC—Valley of the Onny.
LLANDEILO—Shelve.
CAMBRIAN—Longmynds.

Through the kindness of their respective owners and custodians, the following local and private Museums were inspected during the year 1872 :—

The Charles Museum, Maidstone.
Mr. CALEB EVANS' Collection of London Clay Fossils.
The Museum of the Bath Royal Literary and Scientific Institution.
Mr. CHARLES MOORE'S Collection of Jurassic Fossils.
Mr. R. A. C. GODWIN-AUSTEN'S Collection of Cretaceous Fossils.
Dr. HENRY HICKS'S Collection of Cambrian and Silurian Fossils.
The Museum of the Ludlow Natural History Society.

Again your Committee have the pleasing duty of acknowledging great cordiality on the part of gentlemen possessing special knowledge of the districts visited, and they desire to record their high estimation of the services rendered to the Association by the Directors of the several excursions.

To the authorities of the British Museum, the Museum of Practical Geology, and the International Exhibition, the thanks of the Association are also due, and especially so to Professor Owen, Mr. Henry Woodward, Professor Morris, Professor Tennant, and Mr. Robert Daintree, F.G.S., who very kindly gave to the Members descriptive lectures.

Your Committee have also great pleasure in returning their warmest thanks for the hospitality most kindly and liberally offered during the excursions by the following gentlemen :—James Campbell, Esq., The Grove, Hendon; *Coles Child, Esq., F.G.S., The Palace, Bromley; R. A. C. Godwin-Austen, Esq., F.R.S., &c., Chilworth Manor; Jasper Moore, Esq., Linley Hall, Shropshire; and Humphrey Salway, Esq., The Cliff, Ludlow.

The regular and systematic publication of the Proceedings of the Association, commenced in 1871, has been attended with great success, and an entire volume has now been completed. This volume, containing the record of the operations of the Association during two years, will, it is confidently hoped, prove both instructive and interesting to the Members generally.

Considerable attention has been paid to the Library, and the privilege of borrowing books has been largely used. This increased

* The recent death of Mr. Coles Child will be learnt by Members with great regret. Mr. Child's invitation to the Association to inspect the interesting sections on his estate, the warm interest taken by him in the excursion, and the assistance he rendered in obtaining facilities for the observation of everything of geological interest in the neighbourhood of Bromley, as well as his hospitable reception of the very large number of Members who took part in the excursion, sufficiently show that the Association has lost in Mr. Child a valuable friend.

interest in the Library is in some measure to be attributed to the new arrangement by which exchanges of books may be completed in the room in which your Ordinary Meetings are held. The large expenditure for the new book-case, to enable this arrangement to be carried out, has thus been amply justified by this gratifying result, as well as by the greater convenience it has been the means of affording to Members.

In order to allow of the Honorary Librarian attending the meetings of the Committee, and at the same time to facilitate the exchange of books, a Deputy Librarian has been appointed, and your Committee desire to express their best thanks to Mr. John A. Coombs for the zealous and efficient manner in which he has discharged the duties of this office.

The Rev. T. Wiltshire having occupied the Presidential Chair during two years, now retires. Your Committee are quite sure you will join with them in most cordially thanking that gentleman for his services as President.

The long connection of Mr. Wiltshire with the Association, of which he was one of the founders, and over which he presided during the first three years of its existence, as well as the great services he has at various times rendered, call upon your Committee to recommend Mr. Wiltshire, on his retirement from a second presidency, for election as an Honorary Member of the Geologists' Association.

As President for 1873, your Committee have great pleasure in recommending Henry Woodward, Esq., F.G.S., F.Z.S., of the British Museum. Mr. Woodward is so well known in the scientific world, both as an eminent palæontologist and as the Editor of the "Geological Magazine," and has rendered so many services to the Association, both by conducting excursions and by contributing valuable papers, that your Committee feel assured you will give to Mr. Woodward your very cordial support.

While offering again on your behalf the best thanks of the Association to the Council of University College for the continuance of the grant of the Library of the College for the Meetings of the Association, your Committee have great pleasure in adding their acknowledgments for the courteous compliance with the request that your new bookcase might be placed in that room.

The presentation by the Council of the Geological Society of the Greenough Geological Map is another very gratifying act of

courtesy, and one which your Committee have peculiar pleasure in adverting to, since it is an assurance that the great Society to which all Geologists look with respect, fully recognises the value of our operations, and desires to afford that friendly aid which is as important to the one society as it is honourable to the other.

The great educational value of the Geologists' Association is strikingly shown by the number of Members who have, during the past year, been elected Fellows of the Geological Society. You will rejoice in thus finding that your Association is now effectively carrying out the object for which it was founded, and by stimulating the desire for, and by imparting a very considerable amount of Geological information, the Geologists' Association is aiding, in no small degree, in the diffusion of scientific knowledge.

The following Papers were read during the year 1872:—

On the Overlapping of several Geological Formations on the North Wales Border, by D. C. DAVIES, Esq.

Report of the Proceedings of the Geological Section of the British Association at Edinburgh, 1871, by JOHN HOPKINSON, Esq., F.G.S., F.R.M.S.

On the Occurrence of Peat in the Neighbourhood of Finchley, by JAMES T. B. IVES, Esq.

On the Chloritic Marl or Upper Greensand of the Neighbourhood of Cambridge, by the Rev. T. G. BONNEY, M.A., F.G.S., &c.

On the Geology of Hampstead, Middlesex, by CALEB EVANS, Esq., F.G.S.

On a Recently Exposed Section at Battersea, by JOHN A. COOMBS, Esq.

On the Excavations on the Site of the Law Courts, by WILFRID H. HUDDLESTON, Esq., M.A., F.G.S., &c., and F. G. H. PRICE, Esq., M.A.I., F.R.G.S., &c.

On a Visit to the Diamond Fields of South Africa, with Notices of Geological Phenomena by the Wayside, by JOHN PATERSON, Esq., M.A.

On Columnar Basalts, by JOHN CURRY, Esq.

On the Classification of the Cambrian and Silurian Rocks, by HENRY HICKS, Esq., F.G.S.

On the Silurian Rocks of the English Lake District, by Professor ALLEYNE NICHOLSON, M.D., D. Sc., M.A., F.R.S.E., &c.

On Corbicula (Cyrena) Fluminalis, its Associates, and Distribution in Britain, by ALFRED BELL, Esq.

On Specimens of *Ptychodus latissimus*, from the Upper Chalk of Grays, Essex, by OWEN REES, Esq., F.G.S.

On the Dip of the Chalk of Norfolk, and the remains of Old Land Surfaces, called the Stone Bed, by the Rev. JOHN GUNN, M.A., F.G.S.

On the Influence of Geological Reasoning on Other Branches of Knowledge, by HYDE CLARKE, Esq., D.C.L., F.S.S., M.A.I., &c.

On Coal Seams in the Permian at Ifton, Shropshire, by D. C. DAVIES, Esq., F.G.S.

On a Well Section at Finchley, by CALEB EVANS, Esq., F.G.S.

The following is a list of the Excursions of the past year :—

	Directors.
Visit to the Museum of Practical Geology, March 21st.	Professor Morris, F.G.S.
Excursion to Maidstone, April 2nd.	Prof. T. Rupert Jones, F.R.S., F.G.S. Prof. Tennant, F.G.S. W. H. Binstead, Esq.
Excursion to Watford and Bushey, April 13th.	William Whitaker, Esq., B.A., F.G.S. John Hopkinson, Esq., F.G.S.
Excursion to Hampstead, April 27th.	Caleb Evans, Esq., F.G.S. S. E. Pattison, Esq., F.G.S.
Excursion to Erith and Crayford, May 4th.	J. Logan Lobley, Esq., F.G.S.
Visit to the British Museum, May 11th.	Professor Owen, F.R.S., F.G.S. Henry Woodward, Esq., F.G.S., F.Z.S.
Excursion to Bath, May 20th and 21st.	Charles Moore, Esq., F.G.S. Rev. H. H. Winwood, M.A., F.G.S.
Excursion to Guildford, June 1st.	Professor T. Rupert Jones, F.R.S. F.G.S. C. J. A. Meÿer, Esq., F.G.S.
Excursion to Bromley and Chislehurst, June 15th.	Coles Child, Esq., F.G.S. James W. Ilott, Esq.
Excursion to Hendon and Finchley, June 22nd.	Dr. Henry Hicks, F.G.S.
Excursion to Walton-on-the-Naze, July 8th	J. Logan Lobley, Esq., F.G.S.
Visit to the International Exhibition, July 13th.	Prof. Tennant, F.G.S. Robert Daintree, Esq., F.G.S.
Excursion to Ludlow and the Longmynds, July 22nd to 27th.	Prof. Morris, F.G.S. Rev. J. D. La Touche, B.A. Robert Lightbody, Esq., F.G.S.

Your Committee beg to recommend the following list of Officers for 1873 :—

PRESIDENT.

Henry Woodward, Esq., F.G.S., F.Z.S.

VICE-PRESIDENTS.

Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S.
Professor John Morris, F.G.S.
James Thorne, Esq. F.S.A.
Rev. Thomas Wiltshire, M.A., F.L.S., F.G.S., F.R.A.S.

TREASURER.

William Hislop, Esq., F.L.S., F.R.A.S., &c.

GENERAL COMMITTEE.

John Cumming, Esq., F.G.S.
John Hopkinson, Esq., F.G.S., F.R.M.S.
Wilfred Hudleston Hudleston, Esq., M.A., F.G.S., F.C.S.
James William Ilott, Esq.
M. Hawkins Johnson, Esq., F.G.S.
W. H. Leighton, Esq., F.G.S.
Thomas Lovick, Esq.
Charles J. A. Meÿer, Esq., F.G.S.
John S. Phené, Esq., F.S.A., F.G.S., F.R.G.S., F.R.I.B.A.
George Potter, Esq., F.R.M.S.
Professor Tennant, F.G.S., F.R.G.S.
Henry Walker, Esq., F.G.S.

HONORARY SECRETARY.

J. Logan Lobley, Esq., F.G.S., F.R.G.S.

HONORARY LIBRARIAN.

Arthur Bott, Esq., F.G.S.

[*The Treasurer's Account is on the next page.*]

The Report of the General Committee was adopted; and the Honorary Member, and the Officers for 1873, therein recommended, duly elected.

The Thanks of the Association were unanimously voted to the retiring President, and to the other officers for their services during the preceding year.

On the Rev. Thomas Wiltshire, M.A., vacating the Chair, it was occupied by the newly-elected President, Henry Woodward, Esq., F.G.S., F.Z.S., when the Ordinary Meeting for February commenced.

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1872.

Dr.	£	s.	d.
By Balance, January 1st, 1872	102	17	11½
,, Annual Subscriptions and Entrance Fees ...	127	10	0
,, Life Compositions	36	15	0
,, Sale of Publications	7	9	0
,, Interest on Stock (Consold. 3 per cents. £126 16s. 4d.)	3	16	0
	£278	7	11½

Cr.	£	s.	d.
To Printing "Proceedings" and Annual Report	86	6	2½
,, Miscellaneous Printing	11	4	3½
,, Bookbinding	1	12	6
,, Purchase of Books for Library	3	4	6
,, Cost of Bookcase for Library	20	6	0
,, Subscription to Palæontographical Society (1871 and 1872)	2	2	0
,, Gas and Attendance	7	2	6
,, Collector's Commission	0	18	9
,, Postage, Stationery, Porterage, Advertising, &c.	23	9	11
Balance	122	1	3½
	£278	7	11½

We have this day examined the Accounts of the Treasurer of the Geologists' Association, and find that a Balance of £122 1s. 3½d. remained in his hands on the 31st December, 1872.

January 24th, 1873.

(Signed) J. FOULERTON, M.D.,
J. SLADE,
} *Auditors.*

ORDINARY MEETING, February 7th, 1873.

Henry Woodward, Esq., F.G.S., F.Z.S., &c., President, in the Chair.

The following Donations were announced:—

"The Graptolites of the Coniston Flags," by Dr. H. A. Nicholson, F.G.S., from John Hopkinson, Esq., F.G.S.

"On Certain Wingless Insects," by T. W. Wonfor, Esq., from the Author.

"Supplementary List of Works on the Geology, Mineralogy, and Palæontology of Devonshire," by W. Whitaker, Esq., B.A., F.G.S.

"Two Days in a Mining District," by J. Logan Lobley, F.G.S., from the Author.

"On the Stratigraphical Distribution of the British Fossil Brachiopoda," by J. Logan Lobley, F.G.S., from the Author.

"On the Principal Features of the Stratigraphical Distribution of the British Fossil Lamellibranchiata," by J. Logan Lobley, F.G.S., from the Author.

"The 19th Annual Report and Abstract of Proceedings of the Brighton and Sussex Natural History Society," from that Society.

"Proceedings of the South Wales Institute of Engineers," from that Institute.

"Journal of the London Institution," from that Institution.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Proceedings and Transactions of the Nova Scotian Institute of Natural Science," from that Institute.

The following were elected Members of the Association:—

Miss A. B. Potter; G. Elgar Sloper, Esq.; and S. W. Sloper, Esq.

The following Paper was read:—

On the Diprionidæ of the Moffat Shale.

By Charles Lapworth, Esq., F.G.S.

(Abstract).

The Moffat Shale is a well-marked sub-division of the Lower Silurian of the South of Scotland. It is probably the most ancient stratified formation in that district, no indisputably underlying deposit having as yet been detected. It consists of about

600 feet of finely levigated shales and mudstones, frequently black in colour, more or less carbonaceous, and abounding in *Graptolites*. The formation falls naturally into three main divisions, which have been termed respectively the Lower, Middle, and Upper Moffat. The fossils of the Lower and Middle Divisions are those of the Llandeilo Flags of Siluria. Those of the Upper Division are only known in strata of Bala or Middle Silurian age.

The Graptolites belonging to the family *Diprionidæ* of Hopkinson are especially numerous in the Moffat Shale. These the author noticed in detail.

After reviewing the history of investigation among the biserial Graptolites—paying especial attention to the antagonistic opinions regarding the internal structure of the polypary in the genera *Diplograptus* and *Climacograptus* held by Professors Hall and Nicholson—the author stated that the specimens of *Climacograptus* from the Moffat Shale preserved in a state of relief, afford certain evidence that the view of the duplicate nature of the polypary in this genus, as advocated by Professor Nicholson, is substantially correct. On the application of a slight force the compound polypary splits asunder longitudinally down the middle of the septum, and exposes to view the flattened dorsal walls of the composing polyparies. Up the centre of one of these exposed faces runs the virgula, in the form of a fine filiform rod or ridge, which has left a corresponding groove on the surface of the opposing wall. The hydrothecæ are distinct tubes, easily separable from the periderm without the slightest fracture of their inner walls.

On the main point at issue, therefore, these specimens are decisive. It is a matter of fact that a polypary possessing all the external features of Professor Hall's *Climacograptus*, has, in reality, the internal structure which is universally acknowledged to be characteristic of the genus *Diplograptus*.

The author was not prepared, however, to question the accuracy of Professor Hall's conclusion with reference to the morphology of his *Climacograptus typicalis*. As interpreted by himself it points unequivocally in the direction of the genus *Retiolites*, with which, however, its external features forbid us to associate it. This doubtful position it shares with several diprionidian forms from the Moffat Shale, which are allied to the species *Glossograptus ciliatus* of Emmons.

It will be convenient, therefore, to consider the family *Diprionidæ* as being composed of three sub-families, viz. :—

(a) Diplograptidæ—including those species in which the polypary is composed of two monoprionidian polyparies adhering by their flattened dorsal walls.

(b) Retiolitidæ—including those in which the cœnosarc communicates with both rows of hydrothecæ, and the epiderm is, more or less, in the form of a network.

(c) Glossograptidæ—including those forms in which the external features are those of the *Diplograptidæ*, while the internal structure resembles that of the *Retiolitidæ*.

The species belonging to the sub-family *Diplograptidæ* may be provisionally arranged as follows :—

GENUS 1.—CLIMACOGRAPTUS (Hall).

Hydrothecæ perpendicular, without ornament, or furnished proximally with a single median marginal spine.
Polypary tapering; section circular.
Hydrothecæ free, section sub-oval.
Example.—*Climacograptus bicornis* (Hall).

GENUS 2.—DIPLOGRAPTUS (M'Coy).

Hydrothecæ inclined; without ornament, or furnished distally with two lateral apertural spines.

(a) Sub-genus *Petalograptus* (Suess).
Polypary frequently foliiform or sub-fusiform; section various.
Hydrothecæ of the general form of those of *Dichograptus*. (Salter).
Example.—*Petalograptus folium* (His. sp.)

(b) Sub-genus *Cephalograptus* (Hopk.)
Polypary short, triangular, section flattened.
Hydrothecæ linear-tubular, few in number.
Example.—*Cephalograptus cometa* (Gein. sp.)

(c) Sub-genus *Glyptograptus* s-g. nov. (Gr.: *glyptos*. sculptured).
Polypary usually styliform, section concavo-convex.
Hydrothecæ free, section sub-oval.
Example.—*Glyptograptus tamariscus* (Nich. sp.)

(d) Sub-genus *Orthograptus* s-g. nov. (Gr. *orthos.* straight).
Polypary long, prismoid, section square.
Hydrothecæ flattened, section rectangular.
Example.—*Orthograptus quadrimucronatus* (Hall. sp.)

The second portion of the paper was devoted to a revision of the genera and species of the *Diprionidæ* of the Moffat Shale, and several new species were described.*

ORDINARY MEETING, March 7th, 1873.

Henry Woodward, Esq., F.G.S., F.Z.S., &c., President, in the Chair.

The following Donations were announced:—

"Remarks upon the Present State of the Devonian Question," by Horace B. Woodward, F.G.S., from the Author.

"On the Boring at Netherfield," by J. E. H. Peyton, F.G.S., F.R.A.S., from the Author.

"Proceedings of the Geological Section of the British Association, at Edinburgh," by J. Hopkinson, F.G.S., from the Author.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Quarterly Journal of the Geological Society," from that Society.

The following were elected Members of the Association:—

William Bishop, jun., Esq.; G. E. Cruickshank, Esq.; Dr. W. C. Grigg; Robert H. Hoar, Esq.; Charles Henry King, Esq.; John P. King, Esq.; and J. Stratten Thompson, Esq.

The following Paper was read:—

On the Geology of Brighton; Part I.

By James Howell, Esq.

THE SOUTH DOWNS.

That portion of the South Downs, extending from Eastbourne to Brighton, twenty miles long, with an average width of about five miles, the characteristic features of which are of a bold and undulating character, displays a magnificent line of snow-white cliff intersected by three transverse valleys opening into the Weald

* The publication of the figures and descriptions of the new species is unavoidably deferred.

through which meander the Cuckmere and the Ouse, while the third is now riverless. This precipitous cliff-line has also "gaps," rough pathways leading down to the beach, though in many cases difficult of descent. These "gaps" are, in general, the seaward outlets to the higher range of transverse valleys which intersect the cliffs, and at a considerable height above the sea-level—as Rottingdean Gap, Saltdean Gap, Bear's Hide Gap, Hope Gap, and Berling Gap, well-known of yore to Sussex smugglers. The portion of the South Downs included within this area is studded with these higher level valleys and basin-shaped hollows, especially in the neighbourhood of Brighton; nearly every valley or hollow possessing a village or farmstead whose name contains either "dean" or "combe," as an affix or prefix, and situated, with one exception, within, or to the east of the Brighton valley—as Pangdean, Standean, Withdean, Bevendean, Balsdean, Roedean, Woodendean, Ovingdean, Rottingdean, and Saltdean, Seddlescombe, Pyecombe, Combe, Ashcombe, Moulescombe, and Telscombe. Thus have the Celtic inhabitants of the Downs left traces of their existence in the "combes," and in the rivers Cuckmere, Ouse, and Adur—the Saxons in the "deans," the "tons" and "ings," while Norse occupation is shewn by the "rapes" into which Sussex is divided—the Cinque Ports, "Hastings" and "Seaford," the broad sound of "oa" in road and boat, as well as "völlr," "leer," and several other words.

From Beachy Head to the Valley of the Cuckmere, and from the latter to Seaford, the grand and beautiful cliff-line of chalk presents a striking, bold, and precipitous appearance. Being continually undermined by the insidious waves, and portions frequently falling, these cliffs possess as fresh and dazzling a sea-frontage now as they did when first seen by the Romans, who, from their snow-white appearance, gave this island the name of Albion. From Newhaven to Rottingdean they are of less altitude, and from that place to Brighton are much discoloured, containing patches of Coombe-rock or the "Elephant Bed" of Mantell; and from a little beyond Blackrock to the boundaries of the Brighton parish, where the cliffs terminate, they consist wholly of the latter deposit. The last intersection of this portion of the South Downs is the valley in which a great part of the town of Brighton stands; the Race Hill rising boldly on the east to a height of between four and five hundred feet, the western hill being of less altitude (220 feet),

forming the eastern rim of the Hampshire Basin, its western rim being in Dorsetshire. At about one mile due north the valley separates into two, the bottoms of which are respectively occupied by the London Road and the Lewes Road. Between the two valleys rises Round Hill, whose spur, Rose Hill, is at the northern part of the Level. The road up this hill leads to the highest crest of the South Downs, Ditchling Beacon, 854 feet above the level of the sea. Thus the eastern branch of the Brighton Valley leading to Lewes separates the Race Hill from Round Hill, while the western branch leading to London divides Round Hill from the Western Hill, the latter ridge leading to the "Devil's Dyke." The Brighton Valley, thus bifurcating, has not been inaptly compared to the letter Y. The London road follows this course of the western valley as far as "The Plough" at Pyecombe, where diverging a little to the north-west, and in companionship with the Henfield Road, it passes "The Plough" and Pyecombe Church on the right, and finally emerges into the Weald by the way of Dale Gate and Newtimber.

In comparison with those of the Cuckmere and the Ouse, the Brighton Valley is of higher range, without river or stream, except after heavy rains, when the well overflows at Patcham, and then a small stream winds its way along the London Road to the confines of the Brighton parish, where it is conveyed to the sea by a subterraneous channel. Previous to the construction of this sewer, in 1838, this stream used to flow through the streets into the sea, flooding the basements of the houses, in conjunction with the rise and overflow of the wells, and assisted by the drainage of the hills on each side of the Lewes Valley, also laying a considerable portion of the Level under water. But all this inconvenience and unhealthy state of things are now remedied by the main drainage, even the rainfall finding its way into the sea in a few minutes after alighting upon the soil.

The Lewes Valley has no outlet into the Weald, and from the height and contour of the Downs around Falmer, I am strongly of opinion that it never had, for though in several places it winds into the heart of these hills, yet such windings come to an abrupt conclusion at the base of steep escarpments, like the one to the east of Hollingbury. These are the "combes," and may be called latitudinal, in contradistinction to the valleys, which are longitudinal.

Whether the most elevated of the Downs, overlooking the Wealden Area, have ever been under water since their emergence from the Cretaceous Sea, there is little or no evidence from surface indications to prove; whereas there is little doubt that, during the Tertiary Epoch, they formed small islets of little elevation above the sea level, while there is abundance of evidence to prove from blocks of breccia and greywethers scattered over the surface, together with the outliers of the Plastic Clay formation that all their southern portion, to the height of 600 feet, has been, at various times, the bed of the sea; that is, if the pebbles found among the loam on Cissbury Hill are, what they appear to be, of Tertiary origin. The crest of Castle Hill, Newhaven, at a height of 180 feet above the sea-level, is composed of sand and pebbles belonging to the Lower Eocene while the breccia, the base of the Plastic Clay, at Seaford, extended, 50 years ago, from the commencement of the cliffs, capping the Chalk up to the Roman encampment, probably some 300 feet in height; while farther eastward the cliffs are covered with several feet of rich mould, evidently a relic of the Tertiary Epoch. As the cliffs crumble and fall, this loam may be seen filling up the cracks and fissures to the depth of several feet. Now the soil of the South Downs, resting upon a thick stratum of flints, is only a few inches in thickness, so that denudation, sub-aerial, and marine, has not only planed off the whole of the Tertiary strata, but also the upper beds of the Chalk itself down to a considerable distance. The outliers of the Eocene, which that wonderful planer, Denudation, has left us, are at Seaford, Newhaven, Piddinghoe, Brighton, Highdown, Castle Goring, and Binstead, connecting links with Felpham, where the Bognor Series crops out, plainly proving that, at least, the Lower Eocene, was once continuous in Sussex, from Seaford Heights to Bognor, and with the Middle Eocene, on to the extremity of Sussex, and through Hampshire into Dorsetshire.

The rim of this great Eocene basin, viz., the Western Hill, or Montpellier district, Brighton, is covered with the ruins of the Plastic Clay, still lying *in situ* two or three hundred yards to the west, at Furze Hill, at the foot of which begins the Hove Level formed by the retreat of the Downs inland, stretching on into Hampshire; their whole length from Beachey Head being about 53 miles, the valleys of the Adur and Arun intersecting their western, as the Ouse and Cuckmere do their eastern portion.

The whole of the surface seaward of the Downs, west of Brighton, is composed of Recent or Post-Pliocene deposits, the latter overlying the Eocene at Pagham, Selsey, and Bracklesham. From this level district there is a gradual ascent to the crests of the Downs, and to the escarpments overlooking the great Wealden Valley, the coast-line being so low that the waves are ever busy at their work of destruction, the loss of land in a few years being almost incredible. The site of the church at Selsey, founded by Wilfred in 680, is now about one mile seaward, while parks, villages, and churches along the whole coast-line even to Brighton have been destroyed, and their sites taken possession of by the ruthless invader. No one can have a clearer idea of the incessant change to which the earth is subject than he who dwells by the sea and observes its restless doings. Advancing, inch by inch, foot by foot, and yard by yard, does it stealthily creep into, and appropriate the earth's domain into its own bed, planing down and carrying away an old world in order to create a new one.

RECENT MODIFICATIONS OF THE COAST LINE.

The Queen of Watering Places, the Brighton of to-day, extending from Black Rock to Hove Street—stretching along the valleys, climbing the hill sides and covering the hill crests—it would be useless to describe, as everyone knows—

> "How gorgeously,
> A league of Palaces! she skirts the sea."

Such is new Brighton; but old Brighton was a poor miserable fishing village, standing beneath the cliffs where the sea now ebbs and flows. Lyell, in his "Principles of Geology," copying from Mantell, tells us that "in the time of Elizabeth Brighton stood where the Chain Pier now stretches its iron arm across the sea." But this is an error, and coming from so high an authority should be corrected, lest it becomes perpetuated, copied as it is by nearly every compiler of local Guide Books and Histories. The Old Town stood beneath the cliff opposite to the space enclosed between East and West Streets, which, with Black Lion Street, Ship Street, and Middle Street, formed the New Town, and which was built long before the reign of Elizabeth; for the houses of the Old Town gradually retreated from the incursions of the sea, till after the year 1705 the whole of them stood upon the cliffs, and have extended themselves east and west far beyond their ancient limits.

That land and tenements extended to a considerable distance seaward in pre-historic and even in historic times can be gleaned from the following records:— The "Nona Returns" (1340) inform us that between 1260 and 1340, a period of 80 years, the sea had swallowed up 150 acres of land in Hove and 40 acres in Brighton —a loss of 190 acres, giving an average of $2\frac{3}{8}$ acres for every year that had passed! Previous to the 14th century a few houses began to be erected upon the cliff, but after the loss of land above-mentioned the fishermen built East Street and West Street, to which were in a short time added Middle Street, Ship Street, Black Lion Street, and North Street, forming the quadrangular town such as it stood down to a century ago. From 1340 to 1645 we have no records of the encroachment of the sea, but from the latter period to 1655 (ten years) it had destroyed 22 tenements, among which were 12 shops and 3 cottages with lands adjoining, still leaving 113 tenements standing beneath the cliff. From this we may safely conjecture that the loss of land, &c., during the preceding 300 years, must have been something considerable. That it had swallowed up immense tracts may be inferred from the destruction of Aldrington, adjoining Hove, not a single house of this devoted village having been left to mark the site where it once stood. The ruined walls of its little church, some half mile or three quarters from the sea shore, are the only memento of its existence, and a few years since the man at the Pay-gate was the only inhabitant the parish could boast of. Besides this, one of the tenants of the 22 tenements named above also lost 8 acres, to whom, and to other sufferers, the lords of the manors of Brighthelmstone granted fresh lands during the same period. Pretty conclusive proof this of the sea's doings, during the three centuries that history was silent! In 1666 the inhabitants petitioned Parliament for assistance, and were so reduced in 1689 that the parishes of Blatchington, Hangleton, Patcham, and Ovingdean, were ordered by the magistrates at Quarter Sessions to contribute towards the relief of the poor. In the great storm of 1705 the sea swallowed up the 113 tenements beneath the cliff, and by this act completed the destruction of the Old Town. The waves, ever advancing, now threatened the existence of the New Town itself, by undermining and pulling down the friable materials composing the cliff upon which it stood. On came the sea, down fell the cliff, carrying with it the Gun-garden, wall, and gates, in 1734, followed by the ancient fort or Block-

house in 1749. Inevitable destruction seemed impending over the town, and a wail for help went through the land in 1722 and again in 1757, briefs having been obtained to collect money to build and to repair groynes to protect the inhabitants of Brighton from the poverty and suffering inflicted upon them by the continual encroachments of the sea. Groyne followed groyne, raising embankments of shingle on their western sides, which not only proved a barrier to the advance of the sea, but completely drove it back and compelled it to give up, in barren shingle, a small portion of the land which it had devoured.

By this imperfect sketch of Brighton past and present it will be at once seen that the seaward aspect of the Brighton Valley was in past times quite different from what it is now, and that a small river, which eventually dwindled down into a streamlet, flowed through it into the sea. If the popular tradition be true that the town owes its origin to Brighthelm during Saxon times, Brighthelm's ton or town had then fields and meadow lands, farmsteads, and cottages, with gardens and lands, stretching out seaward to a considerable distance, through which meandered a small river, upon whose waters the fishing crafts of that period sailed up to the pool or harbour whose basin is still known as Pool Valley. To the superficial observer of the present coast-line this statement doubtless seems improbable, but history has informed us of the sea's encroachments along the whole coast-line, and a corroboration is to be found in the shallowness of the water off Brighton, the depth of which for three miles seaward does not exceed thirty feet. The five fathom zone all along the low coast-line to the west of Brighton, where the loss of land has been still greater, extends in some places four miles seaward, while to the east, where the coast is lined with precipitous cliffs, it keeps almost close to the shore, especially along the ranges from Seaford to Cuckmere Haven, and from the latter place to Beachey Head. The ten fathom line, off Preston, where, tradition informs us, the Bishop of Selsey's Park once reached, and where the loss of land has been the greatest, is from ten to eleven miles from the shore; while near Beachy Head it is within one mile and a quarter of the cliff. Other corroborative evidence is the discovery of submerged forests along the sea-line from Selsey to near Worthing. So that the voices of history and tradition, the shallowness of the sea's bottom, and the indisputable evidence of submerged forests,

all prove the extension of the Sussex coast for miles seaward, not only during pre-historic, but even historic times.

GEOLOGICAL FORMATIONS.

The Geological deposits upon which the town of Brighton stands, though often considered to be solely Cretaceous, are nevertheless capable of being divided into six, belonging to the Recent Era, the Post Pliocene Era, the Eocene Era, and the Cretaceous Era. We have

I. RECENT.—Silt of the Brighton Valley.

II. POST-PLIOCENE.—Brick-earth, resting on Coombe-rock or Sand. Western Brighton and Hove.

III. POST-PLIOCENE.—Coombe-rock or Elephant Bed, forming the cliffs. Eastern Brighton, Black Rock, Base of the Silt in the Brighton Valley.

IV. TEMPLE FIELD DEPOSIT.—Wrecks of the Eocene and Chalk strata. In the Montpellier district, sloping down the Western Hill towards the Tertiary Outlier, at Furze Hill, and Hove Level.

V. EOCENE.—Plastic Clay, constituting Furze Hill.

VI. CRETACEOUS.—Upper Chalk, or Chalk with flints, forming the hills, and seen on their summits and steep sides.

RECENT DEPOSITS.

The nature of the silt of a river valley can easily be predicted by observing the various formations through which the river and its tributaries flow, by the agency of which the valley is silted up. Soil and flints and chalk-rubble might then be safely predicted as forming the upper portion of the silt of the Brighton Valley, the busy rain-fall for centuries denuding the hill sides of the Recent and Tertiary strata, together with chalk and flints, and tumbling them down into the river to dispose of at its pleasure. If the river flowed with a considerable fall from the Weald, we might also expect to find water-rounded sandstones mingled with the silt, but their Wealden origin would be difficult of proof, as they might be the debris of denuded strata in the more immediate neighbourhood.

Excavations in the Brighton Valley give us the following section:—

1.—Soil or weather-worn flints.

2.—Silt, in the upper portion quantities of flints; in the lower boulders of sandstone.

3.—Brighton Cliff deposit: Coombe-rock or Elephant bed.

4.—Chalk with veins of flint.

That the Brighton Valley was at one time an estuary of the sea into which two small rivers poured their waters, the late excavations to drain the town fully prove.

First there is a dark silt mingled with innumerable flints resembling those of our ploughed land, which in some places reaches to a considerable depth. This is followed by coombe-rock or chalk rubble, rounded by the action of water, and embedded in this deposit occur boulders of sandstone, some of which are of immense size. Hundreds of the smallest of these stones now form borders to the flower beds by the paths in the Pavilion grounds. Mr. Wonfor, Honorary Secretary to the Brighton and Sussex Natural History Society, in connection with myself examined these buried memorials of past ages which speak of a time when the tumultuous waves of an Arctic sea dashed with immense force up the Brighton Valley, as far as the London Road and Lewes Road valleys, then outlets of the waters that denuded the Weald, sweeping its wrecks for miles along their channels into the estuary which then covered the main valley. Ninety-five of these stones out of every hundred were derived either from the Wealden or the Bagshot Series. I am of opinion from the latter, for they are decidedly the same as those spread over the surface of the Sussex, Hampshire, and Wiltshire Downs, known under the appellation of "grey weathers," "sarsenstones," or "Druid sandstones." Of the remainder some are breccia: one of these is a fine specimen of Hertfordshire "pudding-stone." There are a few of granite, but their history as being found in the valley is somewhat apocryphal, especially as they appear to be of the Jersey variety, and which were probably introduced into Sussex, not by the agency of ice, but by that of man. One of the water-rolled sandstones of immense size was dug up beneath the Lewes Road as high as Park-crescent. Everywhere throughout the valley they are embedded at a depth of from twelve to twenty feet. Opposite the Gloucester Hotel, after passing through the silt to the depth of twenty feet, the workmen came to the Brighton Cliff deposit, composed of small pieces of rounded chalk, having the appearance of the bed of a stream. At the bottom of Cheapside this deposit lies eleven feet beneath the surface, mingled with

pebbles resembling those lying upon our present beach. At the junction of the Montpellier with the London Road the same deposit was met with at a depth of seven feet, showing how in the higher portion of the valley the silt that overlies the coombe-rock or chalk rubble thins off. The deposit reaches a considerable distance up the slopes of the hills, but it is nowhere visible on their abrupt and steep ascents.

The hills on each side of the valley, and which were, previous to being built on, escarpments, tell a tale of when they were cliffs whose bases were laved by the waves of the sea, for even now, though rounded and worn down by the attrition of ages, their steepness still reveals this fact. Pool-valley points to a time when that locality was a pool indeed, and the Level a level of waters, fed by rivers issuing from the Weald in the one case, and from the Downs of Falmer in the other; the thickness and quality of the silt indicating that water occupied the whole breadth of the valley. That this era was not antecedent to the Glacial Epoch may be inferred from the fact of the silt reposing upon a bed of Post-Pliocene age. At first the valley was an estuary of the sea, into which flowed rivers possibly through fissures in the Downs, bringing down the *débris* of the denuded Weald, and probably taking their rise in the Downs themselves, sweeping down the Tertiary strata, mingled with the wrecks of the Chalk, which, with the bones of the mammoth, the horse, the ox, and the deer, were deposited in an estuary into which the sea also bore remains of the whale, and shells of an Arctic type, till the deposit rose, layer by layer, above the waves. Then the old sea beach upon which it reposed, and which had also sunk to receive it some 50 or 60 feet, with the hard chalk beneath it, was bodily raised from 12 to 15 feet above its former level. Possibly, previous to this upheaval of the Brighton Cliffs was the elevation of the Downs behind them, closing the flood-gates through which the Weald might have once poured its waters into the valley. Then commenced the drainage of the hills, the wearing down of the cliffs, the silting up of the Brighton levels, the retiring of the sea, and the gain of fertile districts which the restless ocean has once more claimed as its own.

Geological facts tell us that during the Tertiary period, the Sussex coast was submerged and elevated several times, and these submersions and elevations will account for the deposition of boulders of Wealden or Tertiary origin over the surface of the Downs,

and lying in the silt of the Brighton Valley; but it will not account for those of granite, of porphyry, and of slate lying among the shingle of our old sea beach, and in the coombe-rock above it. Whence came they?—for there are no strata of those rocks within one hundred miles of the Sussex coast. Pebbles of the same rocks, too, lie here and there scattered among the shingle, but pebbles travel, and though slowly, might reach hither during the lapse of ages: but not so the boulders, or those immense blocks of plutonic rocks at Pagham and Selsey, some of which measure as much as 27 feet in circumference. Whence came they, then, and how? Sir Charles Lyell suggests from Normandy, or land that once may have existed in the south-west, in what is now the English Channel, transported hither by ice action at a time when the elevated beach in the Brighton Cliffs was a real beach washed by the waves of a cold and stormy sea. Nor is this at all improbable when geological facts teach us that the English Channel has subsided since the period of the great northern pachyderms, when those mammals browsed in a fertile valley where the sea now rolls its waves. Have we any proof of this? Let us see. Mr. Godwin-Austen, in his excellent paper "On the Tertiary Deposits of the Sussex Coast," says, "If we examine the bed of the English Channel, midway between Calvados and Sussex, we meet with features of outline; such as lines of troughs and an advancing platform indicative of an old coast-line; from out of the most northern of these impressions an isolated mass rises nearly to the surface. The bed of the sea in this part of the Channel is remarkably clean, being composed exclusively of sub-angular shingle. I had an opportunity of examining this in 1854, during a calm day, and found the detritus in this portion of the Channel to have been derived partly from old rocks, Silurian of Normandy, and to be mixed with granitic pebbles, and some pebbles of hard, apparently Oolite sandstones, together with Chalk flints." The whole area to the east of this, with an average depth of from twenty-five to thirty fathoms, was then dry land, while the coast-line from England to France was the highway along which pebbles of the Palæozoic rocks of Normandy or Brittany or lands now submerged in the English Channel slowly travelled till they formed a resting-place in our old sea-beach.

A few facts showing how pebbles travel came under my notice during a sojourn in the Isle of Wight last summer. At Bembridge

the beach is a sparse one principally derived from the gravel of the Pleistocene cliff which there caps the Tertiary deposits. Mingled with this sparse beach lie water-rounded blocks of island rocks, derived from the Greensand, which have travelled round from the eastern to the northern part of the island. Some of these stones are of considerable size, so much so as to raise the question of how they travel. If so, go upon the sand covering the Eocene clay, known as the "blue slipper," and you may unravel the problem, for what to us at first sight seems incomprehensible is performed by nature so simply as not only to excite our admiration, but to show us how little our minds are in comparison to the mind of Him who made and governs the material and immaterial world of which we are so minute a portion. Once upon the sands look about you, for everywhere are seen tufts of seaweed moored to angular blocks of "firestone," and which seaweed has floated them hither from beyond the Culvers, where the Greensand lies *in situ*. Raise these tufts, examine them, and you will find them firmly rooted to the stones. Then experiment upon them by placing them in deep water, which will soon convince you that they have the power to buoy them up, and that the tide is fully capable of either floating or dragging them along. Should this experiment be insufficient to settle the question, mark the trails upon the sand which the heavier stones have made, and you will be convinced that this is one of the simple processes which Nature pursues to effect her ends. You may say that these blocks are angular, while those on the beach are rounded by attrition. This problem, too, is a simple one to solve, for when the tide drags them landward they are tossed upon the beach by the waves. The seaweed is broken off, and there it lies rotting and blistering in the sun in every direction, while the stones are dragged to and fro and rounded by attrition. This, then, is one of the thousand and one lessons to be conned upon a sea-beach.

Another fact in connection with this subject was mentioned to me by a friend, who when swimming off Brighton met with an entangled mass of seaweed, and trying to disperse it with a stroke of his hand, struck and injured it against some hard substance, which upon examination proved to be a piece of rock foreign to this coast, to which the seaweed was attached, and by which it was floated lightly and easily upon the surface of the sea. He also met with a similar occurrence when swimming off the Yorkshire coast.

This will show us that Nature is never at a loss for means to effect her purposes.

The blocks of breccia, Druid-sandstone, and lignite embedded in the coombe-rock, are remnants of the Tertiary deposits which once covered the South Downs, for their ruins still cap some of their highest crests, as at Newhaven, Seaford heights, Highdown, and Cissbury, showing the wonderful oscillations of land and sea upon the Sussex coast since the deposition of the Chalk. Facts teach us that these oscillations were not caused by violent cataclysms, but by that scarcely visible process still in operation along our coast line. This is clearly illustrated in the northern portion of the Isle of Wight, which has been gradually subsiding for the last century, and yet the sea level is the same as when Fielding landed at Ryde on his voyage to Lisbon, for he described that place as being inaccessible by sea, except at high water, as the tide left a vast extent of mud too soft to bear the lightest weight. This mud is now covered with a stratum of sand many feet thick, to the east of Ryde, which, however, at low water is not bare to a greater extent than was the former mud-bank. Such are the facts mentioned by Sir Henry Englefield, in his "Isle of Wight." Five miles to the east of Ryde, at Bembridge, during the same period, the sea has swallowed up fields and meadows to a considerable extent, denuded the soil, laying bare the soft slippery mud, over which it is now spreading a thin stratum of sand, which is still dry at spring tides in some places, even out as far as the Fort. Here there is the same deposition taking place as at Ryde. Will the eastern Yar, a tiny rivulet, and the inflowing tide be equal to the task of silting up Bembridge Haven in proportion commensurate with the subsidence evidently taking place? Time alone can answer this question. Whilst the Solent, then, has been sinking, as did the Wealden estuary in the times of old, till it gradually went down to the depth of 1,600 and probably 2,000 feet, the northern portion of the Isle of Wight, from St. Catherine to Dunnose, has during the same period been rising. These facts illustrate the upheaval and subsidence of the southern and northern portions of the South Downs during the Post-Pliocene epoch, denudation by subaqueous action going on in one place and deposition in the other, as shown by rolled "greyweathers" upon the surface of the hills, and sandstones in the silt of the valley.

POST PLIOCENE BRICK-EARTH.

Whether this deposit was derived from Tertiary or Wealden clays is an open question. Much can be said for and against both theories. The Tertiary clays might have been derived from Wealden denudation and the Post-Pliocene Brick-earth of Hove from the Tertiary. With this deposit, however, there are mingled no greyweathers or Druid-sandstones, which may owe their origin either to the Wealden or Bagshot Sands. The Brick-earth of the Hove Level is, in my opinion, far more recent than that of the Temple Field, and even of the Elephant Bed or Coombe-rock. During the excavations on the Stanford estate in the autumn of 1869, a portion of the tusk of the mammoth was discovered in this deposit in a very friable condition, and placed in the local Museum. Two fine vertebræ of a whale were also dug up a few years prior to this discovery. They are now in one of the wall cases in the room containing Mr. Willett's collection of Chalk fossils, having been presented by that gentleman. Many fragments of shells of existing species have also been discovered, similar to those lying in a fragmentary state in the Coombe-rock. The upper portion of the Hove Brick-earth is of a reddish brown colour, while lower down it bears a striking resemblance to the Plastic Clays, such as I saw dug up to form the foundation of a garden wall at Furze Hill last summer. Its appearance was very deceptive, and the remarks of Sir Roderick Murchison, when speaking upon it in his pamphlet on "The Flint Drift of the South-east of England," are perfectly correct. "On a casual inspection," he says, "a Geologist might doubt whether these were really strata of the age of the Plastic and London Clays *in situ*, so completely is their mineral character identical, whilst their eroded upper surface, on which the chief mass of the flint braccia is placed, would seem to separate the two deposits. But both these signs are fallacious, for in the very heart of these clays I found fragments of *Mytilus edulis* and other sea-shells of existing species with their colours preserved, and among them three or four perfect specimens of *Littorina littorea*, a shell whose form and strength enabled it to withstand violence." Sir Roderick thinks that this is pretty conclusive evidence that the Brick-earth of Hove is the equivalent of the Coombe-rock of Brighton, similar remains being found in each, and that both deposits, geologically speaking, are of a very modern date. During

the operations to drain the town last year, I daily watched the progress of the excavations along the Shoreham-road, from Hove Street to the Brighton beach, up to the Toll-house which separates the two parishes.

Opposite Hove Street, and for some distance along the road, the excavations were through sands with scarcely a vestige of Brick-earth. On arriving at Cliftonville the sands were capped with Brick-earth, which increased in depth till opposite Brunswick Square, where the sands were only reached at a depth of 16ft. and 21ft., and the depth of the tunnel at the end of Brunswick Terrace failed to reach them at all, the Brick-earth being succeeded by a dark blue clay of the consistence and appearance of river-mud. Here and there the excavations reached the Chalk, but there was no beach either above or below the sand, and very few pebbles mingled with it. The old sea beach, if really present in these strata, must lie at a considerable distance to the north, for Mantell tells us that it was met with in digging a well in the Western Road at the depth of about 50ft. He does not point out, however, the locality, and from this circumstance I believe he wrote from hearsay; and if so, I am decidedly of opinion that no old sea-beach exists anywhere in the Western Road, as but a few feet of clay, here and there, has to be passed through before reaching the hard Chalk from West Street to Codrington Place, where the Coombe-rock crops out, and which in its turn is soon overlaid by Brick-earth. There has been so much written upon the prolongation of this old sea-beach along the western coast of Sussex from the appearance of a little gravel here and there that I very much doubt of its existence in such localities save at Copperas Gap. Now, these Brick-earth beds of Hove were everywhere capped with gravel, which gravel, with the Brick-earth beneath it, the Coombe-rock of the Brighton cliffs, together with the flint-beds under the turf of the Downs, Sir Roderick Murchison denominates as drift. Every observation made, and every fact discovered by this eminent geologist in the south-east of England are made to conform to his theory of cataclysms. With him everything is suddenly broken up and submerged. Sudden oscillations and violent fractures of the earth's crust causing tumultuous accumulations; all or nearly all of the land animals being destroyed by such catastrophes, followed by a season of quiescence in which the lower portions of our Post-pliocene beds were formed by ordinary shore

action. Theories come and theories go, but the facts on which they are founded still remain. Englishmen, especially if geologists, cannot help theorizing; it is the meat they feed on, the hobby they ride, and without which they could not be what they are, Englishmen. The high road of geological history is macadamised with theory, and of a stratum too, of considerable depth, and future pioneers will form the road of the same material till it finally girdles the earth.

If this Brick-earth is the result of Wealden denudation at so modern a period as the formation of the Brighton cliffs, how is it that we do not find embedded in it Wealden sandstones? There are sandstones in the Coombe-rock, sandstones in the Silt of the valley, but none in the Brick-earth of Hove. The mass of chalk carried away by denudation from the Weald; the Greensands, the Gault 300 feet thick, the Weald Clay of the Forest-ridge, with its uppermost bed the Horsted Sands, and in some places the Tilgate Grit and Worth Sands, are all gone, while a small portion of its clays and nearly all its Chalk flints, spread out over the surface of the Downs or washed into their cavities or fissures, remain. So says theory, but will facts, unless distorted, corroborate it? "Brick-earth," according to Mr. Godwin-Austen, "is the wash of a terrestrial surface, under a far greater amount of rainfall than we have at present; and this, according to my own observations, is correct, fully believing that the terrestrial surface which formed the Brick-earth of Hove was the Tertiary and not the Wealden. The denuded Wealden Clays might have formed the Tertiary, but that the latter formed the Brick-earth of the South Downs there can be but little doubt.

Then as to the age of the deposit itself, facts everywhere tell us that the Coombe-rock rests upon the Chalk, and Brick-earth upon Coombe-rock. In every excavation throughout the town where the two were met with Brick-earth was always the uppermost deposit. Hence the theory of one being the equivalent of the other is unstable—Coombe-rock, and there can be no dispute about it, being decidedly the oldest deposit of the two. Throughout the excavations in Brick-earth few fossils were discovered. At the depth of 17 feet, in the road opposite the commencement of the western portion of Brunswick Terrace, some bones in a very friable condition and two or three teeth belonging to the horse were discovered; these were preserved by Mr. J.

Round, of Brunswick Terrace, and presented by him, through me, to the Town Museum. And this, as far as I am aware, was the only discovery of organic remains in the excavations for the Intercepting Sewer from Hove Street to Brunswick Square.

THE ELEPHANT BED OR COOMBE ROCK.

A section of the Brighton Cliffs shows the following beds:—

1.—Soil.
2.—Weather-worn flints.
3.—Elephant Bed or Coombe-rock, 50 feet.
4.—Old sea beach, 7 "
5.—Sand, 3 "
6.—Chalk with flints, 7 "

This is about the average thickness of the peculiar deposit upon which a large portion of Brighton stands, from West-street to Kemp Town. It is essentially Post-pliocene, and was most probably formed about the close of the Glacial Epoch, previous to the deposition of Brick-earth, probably by sub-aerial and aqueous agencies.

The Brighton cliff deposit, resting upon an old sea-beach, is no longer visible within the boundaries of the parish, having been hid by the sea-wall, to which the town owes its magnificent drive and promenade. Well do I remember, in my boyhood, those loose rugged cliffs, then wave-lashed and undermined, crumbling and falling on to the shingle below.

Though the Brighton cliffs lie hid behind the sea-wall, no geologist need regret the circumstance, for at Black Rock, a little to the east of Kemp Town, the cliffs, composed of Coombe-rock, present fine sections. On visiting them we descend the gap, or path down the cliff, opposite the Abergavenny Inn. See what a mass of weather-worn sharp angular flints cap the cliff. What a formidable array of them are pointed, bayonet-like, towards us on both sides of the pathway at the commencement of the descent. Weapons, sharper than those wielded by Palæolithic savages, guard the narrow path. Avoid their touch, lest a too close proximity may be neither agreeable to your clothes or your flesh. Minutely observe the formation of the cliff, large flints at the top, whose name is legion, angular, not rounded, decreasing in size and number as we descend. The same with the chalk, from large rounded masses to small ones; from the size of boulders to that

of pin's heads. The whole mass has a yellowish buff appearance, with shades of a darker and lighter hue, according to the greater or smaller mixture of Tertiary clays with the Cretaceous fragments, while here and there, varying in size, lie blocks of ironstone, breccia, sandstone, and lignite. Pass eastward along the beach a little farther, and at the base of this heterogeneous mass reposes an old sea beach upon an old sea-washed sand. That beach, though now from 12 to 15 feet above the present one, was once level with it and probably washed by the Glacial sea, and sinking down some 60 or 50 feet received the Coombe-rock or Elephant-Bed upon its shoulders, after which the whole strata were again upheaved to their present elevation.

Is this deposit a stratified one? Webster and Mantell answer negatively; the latter saying it is a confused mass of alluvial materials, varying considerably in appearance and composition in different parts of its course. I dissent from the first portion of this sentence, as in many places, especially in the middle of the cliff, the lines of stratification are very distinct. In a sea beach we perceive the larger pebbles lying at the top which grow smaller and smaller in size as we approach the sea, ending in coarse and fine gravel, succeeded by coarse and fine sand. The same with the old sea-beach, and the same with the chalk and flints in the deposit above it.

The materials composing the cliff seem to have been the result of water action, gently and slowly deposited in a shallow bay or estuary, layer upon layer, while the water continued to grow shallower and shallower, till the accumulation reached the surface. The water next gradually retired, bearing with it much of the finer sediment, while the flints, by virtue of their gravity, remained near the surface, increasing century after century by pluvial action, till they finally attained their present thickness. It was, most probably, the same simple cause which effected the vast flint accumulations beneath the surface of our Downs.

It was the gradual work of ages from causes still in active operation, and not the result of sudden and violent cataclysms to which the elder geologists ascribed the wondrous changes that have taken place both in the organic and inorganic worlds from the beginning, if there ever was such, of the unceasing revolutions of life and matter.

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Dr. Mantell, that great and original observer of the Elephant

Bed of Brighton, gives the following section, commencing from the base of the cliffs :—

1. Upper Chalk or Chalk with flints constitutes about 6 or 8 feet of the cliff. Dipping southwards it extends to an unknown distance into the sea. The Chalk is continued behind the cliff.
2. A bed of fine sand, from 3 to 4 feet thick.
3. Shingle-bed from 5 to 8 feet thick.
4. Elephant Bed, formed of the ruins of the Chalk strata, with intermixture of clay, it is provincially termed Coombe-rock, from 50 to 60 feet thick.

In one of his later works, "The Wonders of Geology," he speaks of this deposit as being obscurely stratified, showing how his expansive mind, ever open to conviction, advanced with his favourite science, of which he was so bright, so able an exponent. The confused heap of alluvial materials, and the cataclysm theory of 1822 had all vanished before the light of science at the time of his death, 1852.

In the old sea-beach there are boulders of granite, of porphyry, slate, and quartz rocks, with rolled masses of chalk, perforated by boring molluscs, and in the Elephant Bed, resting upon it, water-rolled masses of breccia, sandstone, limestone, and lignite ; the former being foreign to this county, while the latter are British.

Previous to the construction of the sea wall, water-rolled masses of lignite or "surturbrand" were plentifully strewn upon the beach, having been washed out of the cliffs by the force of the waves. This lignite was of a highly bituminous character, so much so that even fishermen could not endure the bad smell caused by its combustion, resembling in its excess of bitumen some of the thin seams of lignite in the Ashburnham beds, displayed at Netherfield, where an old quarryman told me he had been induced to burn some, but the smell was so offensive that it drove him out of the house.

The Elephant Bed extends more or less along the line of cliffs from Rottingdean to Brighton, and it is said thence west to Sompting, and if we take the gravel as its equivalent, nearly to Chichester. But nowhere are the same characteristics displayed westward, save at Copperas Gap, as mentioned by Dixon in his Geology of Sussex. In the cutting by the road the bed is there well marked, the sand being seen *in situ* lying under the Chalk-rubble and gravel, with rolled portions of porphyry and granite,

mingled with shells of existing species reposing upon the Chalk. Mr. Samuel Evershed procured many of these shells, and the same gentleman discovered in a layer of clay, beneath the Elephant Bed at Black Rock, fragments of bone in a very friable state, which he considers to have belonged to the red-deer, and the pastern bone of the horse. These are deposited in the Pleistocene case in our Museum. A very fine fossil tooth in the possession of the Town Surveyor, Mr. Phillip Lockwood, was found 17 feet beneath the surface of the southern enclosure of the Steine, when excavating for the Main Sewer in 1866. It was embedded in Chalk-rubble or Drift, met with in many parts of Brighton, quite distinct from Coombe-rock, of which, however, I consider it to be the equivalent. Tusks and teeth of the mammoth have also been discovered in other localities in the Coombe-rock deposit. It was in Dorset Gardens that the workmen found the molar of an elephant. This first gave Mantell the idea of naming the deposit in which it was found, "The Elephant Bed." Most of these remains were embedded in Coombe-rock, resting upon the shingle bed. Others, and these were water-worn, were found in that bed itself. In the excavations made for the foundations of St. Mark's Church the bones of the mammoth were also met with. When this maned and shaggy elephant became extinct is a matter of conjecture. It is now certain that that event was long after the period of the Drift, although not, in my opinion, so recent as some suppose.

Besides the mammoth, the remains of the horse, the ox, the red deer, and the whale have been found in the Elephant Bed. Antlers and bones of the red-deer were discovered in the Western Road, in Lavender Street, and near Preston Barracks. The shells in the old sea-beach and in the deposit above it are of an Arctic type, and in a most fragmentary condition, very few whole ones having been met with.

Mr. Godwin-Austen, in his excellent paper "On the Tertiary Deposits of the Sussex Coast," argues that *Elephas primigenius* existed anterior to the period when our old sea-beach was washed by the waves of the Glacial Sea "from the rolled state of the bones of that animal found underneath the valley in the deep well of the town of Brighton, in the foundation for the sea-wall, and elsewhere in the coast section." But the remains in nearly every case were found, not under the talus, but within that deposit; neither are they all water worn. The teeth in the Museum, and the vertebræ

of whales, for instance, bear not the slightest signs of water action. There is every reason to believe that the mammoth existed in this island during and long after the deposition of the Elephant Bed. Such common occurrences as the discovery of a few water-worn bones are insufficient data on which to found theories; for are not the remains of existing animals in the same condition plentifully scattered among the shingle of our present beaches!

The Elephant Bed, to a careful observer, gives clear evidence of its origin of having been brought there by stream or river, or floods of water, and deposited in layers. All the material composing the cliff, rounded as it is by water action, clearly points to such a result, and yet when Section C of the British Association visited the spot and casually examined the cliff, in August last, they came to the conclusion that the Elephant Bed was formed solely by ice-action. What led them to this belief, so opposed to the views of Webster, of Mantell, and Lyell, and in my opinion to the facts, I am at a loss to conjecture.

Lyell well expresses the view which I, as a painstaking observer, hold of the origin of that mass of deposits which now constitutes the Brighton cliffs.

"First, the southern part of England had acquired its actual configuration when the ancient Chalk cliff was formed; a beach of shingle having been thrown up at its base. Afterwards the whole coast, or at least, a part of it, where the Elephant Bed now extends, subsided to the depth of fifty or sixty feet, and during the period of submergence, successive layers of calcareous rubble were accumulated so as to cover the ancient beach. Subsequently the coast was again raised, so that the ancient shore was elevated to a level somewhat higher than its original position."

A visit to the spot, a little to the east of Black Rock, where the old sea-beach can be seen framed in the cliff at a height of from twelve to fifteen feet above the base of the present one, will, I think, show the correctness of these conclusions.

VISIT TO THE BOTANICAL DEPARTMENT OF THE BRITISH MUSEUM.

MARCH 27th, 1873.

Director :—WILLIAM CARRUTHERS, Esq., F.R.S., F.G.S., &c.

In his descriptive lecture on the collection of plants placed under his care, Mr. Carruthers dwelt upon the points of greatest interest to Geologists.

Commencing with the Cryptogams, it was stated that the forms were nearly as numerous as those of all other orders, but they were rarely found fossil, doubtless owing to their cellular character. Fossil wood from Palæozoic and later rocks is, however, found to contain the mycelium of Fungi. A few mosses have been preserved in amber, and lichen stains have been found on the outer surface of Miocene stems of Bovey Tracey. Notwithstanding the many forms from the older rocks, usually called Algæ, it was doubtful whether any of these were true fossils, though many of them may have been produced by plants. The ferns, and other vascular Cryptogams, were abundantly preserved in the sedimentary rocks, and especially in Carboniferous strata; a well-marked fern *Cyclopteris (Palæopteris) Hibernica* occurring in the Old Red Sandstone. The ferns of the Coal Measures are classified according to their venation, since the fruit has seldom been preserved to us, but venation supplies less important characters than the fruit.

The fronds of ferns, in addition to having the functions of ordinary leaves, produce the organs of reproduction. The stem of a tree fern is a continuous cylinder of scalariform tissue, with openings for the obtrusion of the vascular leaf bundles. The *Alsophila Brunoniana* and the *Dicksonia antartica* are fine examples of tree ferns, The latter is considerably thickened by aërial roots.

The *Lycopodium*, or club moss of the present day, is the representative of the *Sigillaria* and *Lepidodendron* of the Coal Measures, which attained in some instances to a height of 100 feet.

The Equisitaceæ, or mare's tails, had, in palæozoic times, arborescent representatives ; in the Coal period they grew to the height of 30 or 40 feet.

Of the Monocotyledons, the Pandaneæ or screw-pines have fossil representatives in the Northampton Oolites. Palms have not been found in older rocks than the Secondaries.

Coming to the Dicotyledons, Mr. Carruthers pointed out that the Cycads were more nearly related to the Firs than to the Palms. These plants, so abundant in the Secondary rocks, are not found in the Tertiaries. The fruit of the Cycadeæ is dry, with the exception of that of one species, which is fleshy. The fruit of the Yew is in like manner an exception to that of Conifers. A fine section of a Cedar from Chelsea was pointed out. True Conifers have been found in Palæozoic strata, the wood occurs in the Devonian, and in almost every deposit upwards to the most recent formations.

After showing that the Cactaceæ are not related to the *Sigillaria* and *Stigmaria* of the Coal Measures, which were Cryptogams, while the Cacti are true Phanerogams, Mr. Carruthers directed attention to many fine and curious specimens, and to a series of very beautiful transparent sections mounted on glass to show vegetable structure.

A cordial vote of thanks to Mr. Carruthers for his most instructive lecture concluded the proceedings.

VISIT TO THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

April 3rd, 1873.

Directors :—Professor Flower, F.R.S., and Professor Morris, F.G.S.

Professor Morris, in commencing a lecture on the collections illustrating the Invertebrata, after referring in eulogistic terms to the Founder of the Museum, John Hunter, pointed out the value to the palæontologist of the study of the recent forms of life, and the great assistance which such a museum as that in which his hearers were assembled afforded. Not merely were we enabled to perceive the affinities of fossil species, but we were taught the habits of the animals which peopled the earth in the past, and the conditions under which they lived and flourished. Although no great *type* of animated existence has been lost or become extinct, several *Orders*, many families, and—as every geologist knows—a multitude of genera and species have ceased to exist.

The Professor then gave the characteristics of each of the great classes of the Invertebrata, as well as of many of their principal sub-divisions, and illustrated his remarks by the beautiful specimens displayed in the cases of the Western Museum.

The visitors then proceeded to the Middle Museum, in which are

preserved the collections of fossil Vertebrata, including that brought together by Hunter, and were addressed by Professor Flower, the Conservator, who expressed himself not altogether satisfied with an arrangement which separated fossil from recent forms, since all are parts of one continuous whole, and extinction, so far from being a thing of the past merely, is always going on. Passing on to a description of the characters and affinities of the fossil Edentata, illustrated better in this museum than in any other, Professor Flower pointed out the original specimens of Darwin and Owen. Of the Edentata some only are without teeth, but all are devoid of teeth in the front of the jaw. The great habitat of the Order is South America, from which portion of the globe the fossil species have been derived, thus strikingly illustrating the law that the recent fauna of a zoological province is analogous to the fauna which occupied it in the Pleistocene epoch. In Miocene deposits of Germany, France, and Greece, we have, it is true, traces of Edentata, but they are very few and comparatively unimportant; while in South America the remains of the representatives of the armadilloes and ant-eaters are very numerous. Of the largest of these, the *Megatherium* and the *Glyptodon*, the skeletons are complete and well preserved, and reconstruction or restoration is not required, the whole of the hard part of the animal being before us. In addition to the large number of fossil specimens in the museum, diagrams were displayed, showing the structure of the skulls of *Megatherium*, *Mylodon*, *Scelidotherium*; *Megalonyx*, and *Glyptodon*, and the dental and cranial characters of each were lucidly described. Respecting the Megatherium, which represents the sloth as the Glyptodon does the armadillo, the lecturer agreed with Professor Owen in the conclusion that it lived on the leaves of trees which it overthrew, and for which feat of strength the Megatherium was completely fitted by its remarkable structure.

A vote of thanks to the learned lecturer was cordially given, and the visit then terminated.

ORDINARY MEETING, April 4th, 1873.

Henry Woodward, Esq., F.G.S., F.Z.S., President, in the Chair.

The following Donations were announced:—

"Systême Silurien du Centre de la Bohême," by J. Barrande; from the Author.

"Crustacés divers et Poissons des Dépôts Siluriens de la Bohême," by J. Barrande; from the Author.

"On a new Sub-Class of Fossil Birds."

"On the Gigantic Fossil Mammals of the order Dinocerata," by Professor O. C. Marsh; from the Author.

"On the Discovery of Additional Remains of Pterosauria, with Descriptions of two New Species," by Professor O. C. Marsh; from the Author.

"On the Discovery of the Dermal Scutes of Mosasauroid Reptiles," by Professor O. C. Marsh; from the Author.

"On the Structure of the Skull and Limbs in Mosasauroid Reptiles, with Descriptions of New Genera and Species," by Professor O. C. Marsh; from the Author.

"Preliminary Descriptions of Hesperomis Regalis, with Notices of four other New Species of Cretaceous Birds," by Professor O. C. Marsh; from the Author.

"Abstract of Proceedings of the Geological Society of London;" from that Society.

"Journal of the London Institution;" from that Institution.

The following were elected Members of the Association:—

James Grieve Lorrain, Esq.; Charles T. Mitchell, Esq.; Miss Bessie Seel; and Bernard H. Woodward, Esq.

The following Papers were then read:—

1. On the Origin and Present Position of the Diamonds of South Africa.

By G. C. Cooper, Esq., of Graaf Reinet.

(*The Publication of this Paper is Deferred.*)

2. On Some Fossils from the Margate Chalk.

By John William Wetherell, Esq.

During the last few years I have paid several visits to Margate with the view of inhaling the fine sea breezes of this favourite watering place, and also of enjoying occasional rambles along the cliff and shingle in quest of geological treasures. My researches having been more successful than I at first anticipated, I thought it would be desirable to lay before the Members of the Geologists' Association the results of these explorations.

I will in the first place give some account of the localities from

which I obtained my specimens. The coast line of Chalk between the Clifton Baths and Jetty is irregular, and pierced by numerous caves, all of which open in the same direction. The upper portion is more broken and angular than the lower. It is from the lower $\frac{1}{10}$th that I obtained the various fossils, most of them occurring irregularly, with the exception of the Oyster-bed and ferruginous beds with organic remains.

The following section will explain the general character of the Cliff :—

GENERAL VERTICAL SECTION OF THE MARGATE CHALK.

Total thickness of the Cliff about 60 feet.
—Vegetable soil.
—Sand pipes.
—Flints within and without pipes.
—Flint bed.
—Fractured chalk.
—Organic remains with ferruginous stains.
—Bed of organic remains with ferruginous stains.
—Marked or banded flints, Fucoid remains? Ventriculites, Foraminifera, Asterias, Apiocrinites, Belemnitella, Terebratulina, Cup coral, Bryozoa, Marsupites, Ostrea, Inocerami, Spines of Echini, &c.

LIST OF THE FOSSILS.*

C. Signifies that the fossil was common.
V. C. Very common. R. Rare. V. R. Very rare.

Plantæ.

Fucoid Remains ? R.

Amorphozoa.

Cephalites longitudinalis. R.
Choanites Konigii. R.
Siphonia. R.
Spongia ramosa. R.
And other species.
Talpina dendrina. R.
„ ramosa. R.
„ solitaria. R.
Ventriculites radiatus. R.

Foraminifera.

Coscinopora globularis. V. C.
Other species undetermined.

Zoophyta.

Parasmilia centralis. R.

Echinodermata.

Ananchytes cónoideus. C.
„ pyramidatus. C.
Apiocrinus ellipticus. C.
Pentacrinus. V. R.
Comatula. V. R.
Cardiaster. V. R.
Cidaris clavigera. R.
„ sceptrifera. R.
Cyphosoma. R.
Micraster cor-anguinum. C.
Salenia granulosa ? V. R.
Marsupites lævigatus. R.
„ Milleri. C.
„ ornatus. C.
Oreaster. R.

Annelida.

Serpula plexus. C.
„ turbinella. R.
And four other species.

Cirripedia.

Xiphidium maximum. V. R.

Bryozoa.

Flustra. R.
Lunulites radiatus. C.

Crustacea.

Astacus Leachii. V. R.

Brachiopoda.

Crania Parisiensis. R.
Magas pumila. C.
Rhynchonella plicatilis. R.
Terebratula cornea. R.
Terebratulina striata. C.

Lamellibranchiata.

Exogyra. R.
Inoceramus. C.
Ostræa—(several small species).
Pecten quinquecostatus. R.
„ sp. R.
Spondylus latus. R.
„ spinosus. R.

Gasteropoda.

Hipponyx. V. R.

Cephalopoda.

Ammonites. R.
Belemnitella mucronata. C.
„ quadrata. C.
„ sp. C.

Pisces.

Tooth of Galeus pristodontus. V. R.
Tooth of Saurodon leanus. V. R.
Spine apparently of a species of Balistes. V. R.

The following observations on some of the fossils in the above list, and references to figures in the published works on geology may be useful.

Fucoid Remains.—These consist of branched stems on the outside and within some of the flints.

* Besides the fossils enumerated in this list, several others have been obtained. As, however, the species have not been satisfactorily determined, I thought it would be better to omit them.

Talpina Solitaria.—Inside a fragment of *Belemnitella.*

Coscinopora globularis.—It is really surprising how many specimens have been collected at Margate. They vary in size from that of a large walnut down to a pin's head, and are occasionally attached to flints. Some years since above a thousand were procured at low water from the shingle between Brighton and Kemp Town.

In Morris's catalogue *Coscinopora* is placed with the Amorphozoa, but it is now considered to be one of the Foraminifera.

Body of a Comatula.—This is very rare. It also occurs at Gravesend, Maidstone, and Westphalia. It is the *Glenotremites paradoxus* of Goldfuss.

Oreaster.—From a careful examination of a large number of detached bones of the asterias, it is quite evident there are several species.

Xiphidium maximum.—Only one specimen has been found. See "Dixon's work On the Fossils of the Tertiary and Cretaceous Formations of Sussex," &c. 4to. 1852, Tab. xxviii., f. 6.

Astacus Leachii.—See "Mantell's Fossils of the South Downs," 1822, p. 221, t. xxx., f. 2.

Terebratulina striata.—This beautiful shell, in some respects, comes very near to the *Terebratulina striatula* of the London Clay. Of this latter shell my father, Mr. Wetherell, has several detached valves, from the London Clay at Finchley, about two miles to the north of Highgate. Two of the valves exhibit the loops appertaining to the hinge, which is very interesting, as in most cases the shells are filled with iron pyrites.

Hipponyx sp.—See "Dixon's Fossils of Sussex," t. xxvii., f. 8.

Saurodon leanus.—See "Dixon's Fossils of Sussex," p. 373, t. xxx., f. 28-29.

Balistes.—See "Mantell's Fossils of the South Downs," 1822, p. 229, t. xxxiii., f. 5-6.

Shark Remains.—In 1869 I extracted from the Cliff of Margate, near Hodge's Bridge, two large squaloid vertebræ in a fine state of preservation. The diameter across was about $1\frac{5}{8}$ inches, and the thickness $\frac{5}{8}$ of an inch.

For a figure of the tooth of *Galeus pristodontus*, see "Mantell's Wonders of Geology," 1839, Vol. 1, p. 329.

My friend, Mr. Dowker, in his able paper,* speaks of his having

* "On the Chalk of Thanet, Kent, and its Connection with the Chalk of East Kent." By George Dowker, F.G.S. Published in the "Geological Magazine" for October, 1870.

two species of ammonites from the Margate Chalk, and one of them was so large as to measure nearly three feet in diameter. Between Brighton and Kemp Town, some years since, might be seen at low water portions of the outer whorls of very large ammonites, imbedded in blocks of chalk, half buried in the shingle. They were too much water-worn for specific identification.

Small belemites are very common. They are also met with in the Upper Chalk of Gravesend and Northfleet, and are there known to the pitmen by the name of pencils. Some banded flints were obtained; they are, however, rather scarce. At Brighton they have also been found, on the beach, opposite the King's Road. See Dr. S. P. Woodward's paper, "On the Nature and Origin of Banded Flints," in the "Geological Magazine," No. 4, for October, 1864.

I believe minerals are rare in the Chalk of Margate. I certainly have not discovered many at the part where I explored. I have obtained one round specimen of sulphide of iron, the size of a marble, and a mass of iron pyrites from the centre of a flint. I have also found some crystals of sulphate of lime adhering to a fragment of the whorl of an ammonite. The chalk was soft, marly, or hard, according to the part of the Cliff whence it was taken.

It will be observed that I have in this paper several times called attention to the Brighton Chalk containing fossils of the same description as those found at Margate.

The following additional genera may be enumerated as having been obtained from both places:—*Choanites*, *Parasmilia*, *Apiocrinites*, *Marsupites*, and star-fish.

As one of the main objects of this paper is to place on record the largest number of names of the fossils obtained from the Margate Chalk, very little has been said about the geological features of the Cliff, excepting at the places where the explorations were made. I would, therefore, refer those of my geological friends who wish to have more detailed information respecting this part of the subject to the papers of Mr. Whitaker and Mr. Dowker, from which they will derive the information they desire to possess.

I should very much like to see a good list of fossils from Broadstairs. Although the specimens correspond with those from the Margate Chalk, further research might bring to light some fresh

forms. Lately a young friend of mine, Mr. Walter Sanderson, brought away (as the result of one visit) more than a hundred specimens. It is true many of them were duplicates, but it is sufficient to shew that much may be done at this place in the collection of organic remains.

EXCURSION TO BANBURY,

April 14th and 15th, 1873.

Directors:—Professor Morris, F.G.S., and Thomas Beesley, Esq., F.C.S.

(Report by Mr. Beesley.)

The party, which was a large one, arrived at Banbury at an early hour, and without loss of time commenced an inspection of sections in the immediate vicinity of the town.

The first visit was to some clay-pits on the south-west of Banbury, where the *Ammonites capricornus* and *Ammonites margaritatus* beds of the Middle Lias are imperfectly seen. Excavations are rare near the town, and go but little below the surface. Few fossils were noticed. Afterwards a small quarry of Marlstone (*Ammonites spinatus* zone), near the Infirmary, was visited, and a few of the common fossils obtained. The cannon-ball structure of the Marlstone, disclosed by weathering, was noticeable here. The *Ammonites Henleyi* beds are now nowhere exposed.

After luncheon the party in carriages took the road towards Oxford. Turning to the east, after a drive of rather more than two miles over the Marlstone plateau, with here and there patches of Upper Lias, the road gradually falls towards Twyford Wharf, on the Oxford Canal, where an extensive excavation for brick and tile-making shows the *Ammonites margaritatus* beds resting upon the *Ammonites capricornus* marls (Lower Middle Lias). An irregular band of hard siliceous marlstone, the base of the Marlstone series, occurs here, containing a rather peculiar assemblage of fossils. Above this is a thin bed of sand, and then about 15 feet of sandy marl and shale underlying the Marlstone rock-bed. In this spot, chiefly from the lower marls, and often from nodules, many fossils were got, including *Ammonites margaritatus* and *A. Henleyi* (the latter not previously found so high up), *Belemnites*

paxillosus and *B. clavatus*, *Pleurotomaria rotelliformis*, *Cardium truncatum*, *Cypricardia cucullata*, very common here; *Plicatula spinosa*, large and with nacreous interiors; *Modiola scalprum*, *Rhynchonella variabilis*, &c. *Serpulæ* were abundant in the siliceous marlstone. A similar stone was formerly quarried for road metal at Warkworth, three miles north-east, on the opposite side of the river, which afforded many interesting fossils. Bones of *Ichthyosaurus* and coprolites, as well as crustaceans have been found at Twyford.

Professor Morris directed attention to the fine state of preservation of the *Plicatulæ* and other attached shells, which showed that they had lived and died upon the spot, in a shallow and quiet sea.

Passing over the Cherwell into Northamptonshire, King's Sutton church, famous for its graceful tower and spire of perpendicular work of the 15th century, was hastily inspected under the guidance of the Rev. W. Buckley, Rector of Middleton Cheney, and William Willes, Esq., who met the party here. King's Sutton Ironstone Quarry, situated three-quarters of a mile south of the village, and not far from the Great Western Railway, with which it is connected by a tramway, was next visited. The following is the section :—

	Ft.	In.
Soil, very sandy and ferruginous . . .	2	6
Marlstone, with *Rhynchonella tetraedra* . .	0	8
Marlstone	2	6
Marlstone, with *Rhynchonella tetraedra*, *Terebratula punctata*, and *T. resupinata*	1	0
Marlstone, with pebble-like concretions . .	1	0
Rusty ferruginous concretions	1	8
Sandy blue marl and grey shale.		

The concretions are highly phosphatic. The iron in the stone averages 23 per cent.

Many rare and interesting fossils have been found in this quarry, chiefly from weathered blocks of the stone; but upon the present occasion few of the latter were to be seen, yet some good things were secured, including a fine mass of coral, apparently a *Septastræa*. Several species of corals have been lately found here—rare things in the Marlstone.

Returning to King's Sutton, the route was by Astrop Wells, a

rather fashionable health resort in the 17th and 18th centuries, up Newbottle Hill, where junctions of the Middle and Upper Lias, and of the latter with the siliceous limestones of the Inferior Oolite (Northampton Sands) were traced, to Newbottle Spinney, where are the remains of large quarries in the Inferior Oolite, and where many Roman remains—coins, pottery, dishes, or *paterœ* of pure tin, &c.—have been found. Across the eastern end of this Spinney passed the whirlwind of November 30th, 1872; and within it striking remains of the shattered and prostrated trees were still visible. This whirlwind had its origin near the brook at Walton Grounds, about a mile S.S.W. A slender column, looking like smoke or steam, was suddenly shot down from the strongly agitated clouds to the earth. Revolving with great velocity from right to left, it advanced rapidly in a N.N.E. direction, breaking and overturning great trees in its course. After passing the Spinney it threw down the wall of Newbottle Park in many places, hurling the stones to the west. Here it was observed to send out flashes or sparks of red light (probably electric discharges) to the ground. At the brook beyond, it made great havoc amongst the trees. After this it became invisible, but was traced by its effects two or three miles further. In a slab of Inferior Oolite limestone from a wall a specimen of the problematical fossil, believed by Dr. Bowerbank and others to be a sponge, and first discovered at Milcomb Hill, on the other side of Banbury, was found. Many specimens had previously been found by Mr. Beesley and Mr. E. Walford in the broken-down wall of Newbottle Park. Here Professor Morris gave a very interesting field-lecture on the physical geology of the district, especially explaining the process by which the Lias valleys had been excavated, and pointing out that the Marlstone and Oolite table-lands had been preserved from destruction by the resistance offered by their stony bands.

On the return to Banbury the Members and their friends dined together at the Red Lion Hotel; and in the evening the Members were entertained at a Conversazione in the Town Hall of Banbury. A very fine collection of the Local Fossils, as well as of the Antiquities of the neighbourhood had been brought together by the exertions of Mr. Beesley, and a large assembly testified to the interest which the visit of the Association had occasioned. During the evening Professor Morris delivered a lecture, in which he described generally the geology of Banbury,

and enlarged upon the advantages to all of the study of a science which taught the history of the formation of the earth as we now find it, and which, in an especial manner, familiarised us with the operations of Nature.

On the following morning the Members were early astir. Passing out of the town in a westerly direction their attention was drawn to the fact that they were now upon the Upper Lias, whilst at the top of an adjoining field they could see the general level of the Marlstone 100 feet above them. A fault ran along the road by which they were going, but the depression was not all produced by this. At the top of the field just mentioned Mr. Beesley pointed out an excavation called the "Bear Garden," which Dr. Stukely and others had described as a Roman Castrensian Amphitheatre. It is probably nothing more than an old stone pit, subsequently adapted for bear and bull-baiting. No Roman remains have been found in or about it. A little further the Marlstone was seen cropping out on the left side of the road, whilst on the right, or lower side, the Upper Lias had been found in well-sinking to be 20 feet thick. Half a mile from Banbury a halt was made at some brickyards, showing the Upper Lias Clay, capped by the Inferior Oolite. Constitution and Crouch Hills, between which they stood, were mainly composed of Upper Lias; but the former, let down by the fault already noticed, and a still larger one marked in the Survey map, running from Hardwick on the north east to Broughton on the west, and producing a displacement of 100 feet, showed Inferior Oolite, capped by the lower beds of the Great Oolite. Fossils were abundant in the latter, especially *Terebratula maxillata*, *Rhynchonella concinna*, *Ostrea Sowerbyi*, *Echinobrissus clunicularis*, *Clypeus Plottii*; but the pits were now filled in. At "Bretch," a little beyond, Marlstone was seen rising above the Upper Lias, and much tilted to the south. Here a cave in the Marlstone was noticed, evidently having some connection with the fault. It is not likely that it contains fossil bones, or flint implements. Broughton Church—a most interesting building of early 14th century work, with a "broach" spire, a stone chancel screen, and some fine tombs of the De Broughton, Wickham, and Fiennes families—was next visited, where the Rector and Mrs. Wyatt met and welcomed the visitors, some of whom took the opportunity of inspecting the Castle—a highly picturesque erection of the 14th, 15th, and 16th

centuries, and noted in the early period of the Civil War as the seat of the Puritan leader, Viscount Saye and Sele.

After this archæological digression, the party made their way to the quarry near Broughton Fulling Mill, where the upper beds of the Great Oolite—here let down by a double fault and dipping considerably to the brook on the south—are quarried for lime-burning and road-stone. The following is the section at the lower end of the quarry :—

	Ft.	In.
Soil	1	0
Oolite, upper part broken	6	0
Sandy shale	0	0½
Oolite	1	4
Sandy shale	0	0½
Oolite	1	0
Oolite	4	0

Near the top of the quarry the beds are broken by small faults, and are capped in places by some grey slaty layers resembling Forest Marble. It was suggested that any decision as to these should be adjourned until the other neighbouring sections had been seen. One or two corals and a few other fossils were found here. It was the opinion of Professor Morris that the inclined position of the beds was due to a "roll" rather than a "fault."

Passing the brook and ascending the opposite hill, another Great Oolite quarry, called in Mr. Beesley's paper on the Geology of Banbury, the "Tadmarton Lime-kiln Pit," was soon reached. This, as evidenced by fossils, showed the lower, but not quite the lowest beds.

SECTION.

	Ft.	In.
Soil and broken stones	5	0
Oolite	1	0
Shaly marl, many fossils	3	6
Oolite (in two beds with marly parting)	5	0

Many fossils were secured, including a small coral, *Glyphœa rostrata*, *Pholadomya Heraulti* and *P. socialis*, *Cypricardia Bathonica*, *Modiola cuneata*, *Thracia curtansata*, *Astarte*, *Leda*, *Cyprina Loweana*, *Ceromya undulata* and *C. Bajociana*, *Eulima com-*

munis, Cylindrites, Natica, Terebratula maxillata and *T. perovalis, Echinobrissus clunicularis, Clypeus Mülleri ? Acrosalenia*, &c.

A quarter of a mile to the south, is another quarry, the "Tadmarton Forest Marble Pit." It shows the grey shelly and slaty beds previously mentioned still more distinctly than the Fulling Mill Pit. These beds are coloured as Forest Marble, let down by a small fault, in the Survey map; but some geologists have been inclined to think them shelly beds, similar to those of the Forest Marble, intercalated in the ordinary Great Oolite series. Upon the present occasion, however, the question was decided in favour of the view taken by the Geological Survey; for on approaching the quarry from the N.E. many fossils were picked up from the surface of the ploughed field, which Professor Morris and others at once identified as belonging to the Cornbrash (*Avicula echinata, Terebratula obovata, Anabacia orbulites*).

A section was taken by Professor Morris, which is probably more correct than the following:—

	Ft.	In.
Soil	1	6
*Slaty Forest Marble	1	3
Limestone	1	0
Shale (or Marl)	1	0
Grey Clay	0	9
Black Clay, with jet, thinning out to north	1	0
Oolite, quarried to	10	0

The oolite of this quarry is hard and compact, often blue within. From it were obtained the fine series of bones of *Teleosaurus brevidens* and *T. subulidens* of Phillips, as well as a paddle-bone of an *Enaliosaurian*, and a few small bones, doubtfully referred to *Ramphorhynchus*, in Mr. Beesley's collection. *Ostreæ* and *Gervilleæ* are abundant in the clay below the Forest Marble; but the ordinary Great Oolite fossils are scarce here.

Tadmarton Heath, an elevation of 340 feet above the Cherwell, and 680 feet above the sea, covered by the loose sands of the Inferior Oolite (white, yellow, and red) was next sought. Here rises the Holywell brook, an affluent of the Cherwell, and finally of the Thames; as well as the Stour, whose waters flow westward, to mingle with the Warwickshire Avon and the Severn. On the

* A greater thickness of this is shown by the field road.

summit of the heath is a fine circular British camp, with a quadrilateral outwork guarding the entrance on the east. From it a paved way led to the very copious and pure Holywell Spring, and many Roman coins and other remains have been found about it. Two tumuli stand about 400 yards to the north-west, and the square camp of Hooknorton is distant three quarters of a mile west-south-west; whilst the camp of Madmarston, and the site of the Romano-British settlements below it are seen two miles off on the north. Within the precinct of the camp a welcome luncheon was spread, for which the fresh though balmy air and the morning's work had given an appetite. After luncheon Professor Morris took an opportunity of proposing a vote of thanks to Mr. Beesley, which was seconded by Mr. Lobley, and carried by acclamation.

Turning eastward Milcomb Hill, showing the junction of the Inferior Oolite and Upper Lias, was descended; but no halt was made at the spot where the supposed sponge, already mentioned, was found, as it was understood that the pits were closed; but a few Inferior Oolite fossils were got from some broken stone on the roadside, and some crystals of *Selenite* were collected from the Upper Lias clay. A short stay was made at Bloxham to give the party an opportunity of examining the fine church of Bloxham, with its magnificent tower and spire of the 14th century, of exquisite design and proportion, and 195 feet in height, and its fine "decorated" windows and doorways. A few minutes were spent in the interior, where attention was drawn to the windows of the chancel, which although evidently built in the 14th century, showed the zigzag and other well known mouldings of the 12th century. They had evidently been reconstructed with the materials of a former church.

Combe Hill, Barford, was the next halting place. Here the Inferior Oolite rock-bed, first detected by Mr. Beesley, is let down by two parallel faults, half a mile apart, between which the river Swere runs eastward to join the Cherwell. The rock is thick-bedded with partings of marl or sand, and is oolitic, shelly, or compact, and nearly white. It dips to the south. Its exact position is not quite made out, but it is probably low down in the series. The resemblance to the Bastard Freestone was noticed. Its fossils, which are numerous, generally differ from those of the so-called Northampton Sands to which the yellow-brown sandy flags and lime-stones of Milcomb Hill and Newbottle are referred.

Many species were collected, including *Nautilus Baberi*, *Belemnites* sp., *Natica Leckhamptonensis*, a large *Pleurotomaria*, *Trigonia Beesleyana* (Lycett), *Perna quadrata*, *Lima grandis*, *L. pectiniformis*, *L. cardioides*, *Peoten lens*, *Hinnites abjectus*, *Terebratula submaxillata* *T. perovalis* and *Thamnastræa Defranciana*. At Blackingrove, on the other side of the river, the same beds were quarried, even in Roman times; and from these the late Mr. C. Faulkner, F.G.S., of Deddington, had two or three species of ammonites, *Pholadomya fidicula*, *Pygaster semisulcatus*, and other Inferior Oolite forms. Mr. Beesley has more than fifty species from the two localities, most of which are exclusively Inferior Oolite fossils.

On returning, a view was obtained of Adderbury Church, thus adding the last of the three fine churches of the neighbourhood to the visitors' list. The extensive ironstone quarries east of Adderbury were next examined. These show 11 or 12 feet of Marlstone in two or three beds, capped by three or four feet of Upper Lias (Cephalopoda beds and whitish clays). The beds show many vertical fissures filled with Upper Lias, and are a little shifted and tilted, "so as," as is remarked by Professor Phillips, "to make frequent parallel waves about a foot high." The stone is in large blocks, brown on the exterior, bluish-green within, where it has an oolitic appearance from the presence of lenticular grains of ferrous silicate. The two Rhynchonella beds are well marked; and the thin top bed, forming a transition to the Upper Lias, contains ammonites of Upper Lias type, and many fine gasteropods. Unfortunately the spoil-banks made up of this and the Cephalopoda beds, from which so many interesting Marlstone and Upper Lias fossils had been obtained, had just been filled into the excavations, so that little was got during the short time the party was able to stay. The ferruginous Marlstone here contains from 18 to 24 per cent. of iron. Below the Marlstone, and separated by three feet of shale, is a bed of grey shelly limestone; and below this a rusty concretionary bed.

After the section had been explained by Mr. Beesley, and a little time had been spent in its examination, the Members again took their seats in the carriages, and a rapid drive to Banbury brought to a close a most instructive excursion.

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY.

APRIL 21ST, 1873.

Director—ROBERT ETHERIDGE, Esq., F.R.S.

This, the first evening visit of the Association to a Museum, was intended to afford a convenient opportunity to Members to make themselves acquainted with the arrangement, and, to a certain extent, with the contents of this national depository for the fossils of the British Islands.

On the visitors assembling they were conducted by Mr. Etheridge to the lower of the two galleries which encircle the Great Hall, and which contain the Palæontological Collection.

The fossils are exclusively British, and the arrangement is stratigraphical. It will at once be seen, therefore, that the student may find without difficulty the prevailing fossils of any formation, the palæonotological characteristics of which he may be desirous of studying. In addition to this simple and very advantageous arrangement, the linear extension of the cases is so great that a zoological classification of the fossils of each formation or *System* is carried out with considerable completeness. Little is left, therefore, to the student to desire in this beautiful Museum, with which every lover of Geology ought to make himself intimately acquainted.

Mr. Etheridge described generally the fauna of each geological System as represented by the contents of the cases brought under the notice of the visitors, commencing with Cambrian and Silurian fossils and ending with the organic remains from the latest deposits. The party were afterwards shown the method of registering the specimens found by the officers of the Geological Survey, the completeness and elaboration of which surprised the visitors not a little, and they testified their gratification at what they had seen and heard during the evening by a hearty vote of thanks to Mr Etheridge, to whom geological students are so much indebted.

EXCURSION TO CHARLTON.

APRIL 26TH, 1873.

Director—Professor MORRIS, F.G.S.

The well-known section at Charlton showing the junction of the English Secondaries and Tertiaries was first visited. Professor Morris, after pointing out to the large party assembled around him

in the great chalk pit the general character of the Chalk and the Lower Eocenes as they occur in the British Islands, described their foreign equivalents, and the beds which are probably intermediate in age between the Upper Chalk and the Thanet Sands of England. Though we find in our home section the Thanet Sands lying conformably on the Chalk, it is more than probable that we have lost some hundreds of feet of chalk, either by sub-aërial or sub-marine denudation, or by decomposition after the deposition of the superincumbent sands. That some of the Chalk has been removed by decomposition is evident from the occurrence of the well-known bed of green-coated flints at the top of the Chalk, which bed must have been formed by the quiet and slow removal of the Chalk in which the flints were originally imbedded.

The Thanet Sands and Woolwich and Reading Series are both of very limited extension in England, the former formation extending only from Pegwell Bay to a little to the west of London; yet the *Sables de Bracheux* and the *Argile plastique* of the continent of Europe shows us that the original extension of these formations was by no means inconsiderable.

Leaving the great Chalk and Thanet Sands Section, the party were conducted nearer to the town of Woolwich, where a fine exposure of the Shell-beds of the Woolwich and Reading Series reposing on the Thanet Sands gave an opportunity for the collection of some of the estuarine shells which are so markedly characteristic of the Woolwich Beds. *Ostrea pulchra* and *Cyrena cuneata* almost form the Shell-beds, but intermingled may be found many specimens of *Melania inquinata* and *Cerithium funatum*.

ORDINARY MEETING, May 2nd, 1873.

Henry Woodward, Esq., F.G.S., F.Z.S., &c., President, in the Chair.

The following Donations were announced:—

"On the Wealden as a fluvio-lacustrine formation, and on the relation of the so-called Punfield Formation to the Wealden and Neocomian," by C. J. A. Meÿer, F.G.S.; from the Author.

"Further Notes on the Punfield Section," by C. J. A. Meÿer, F.G.S.; from the Author.

"Abstract of Proceedings of the Geological Society;" from that Society.

"Journal of the London Institution;" from that Institution.

"Transactions of the Woolhope Naturalists' Field Club, for 1871;" from that Club.

The following were elected Members of the Association:—

Frederick Berry, Esq.; Rev. John Clifford, M.A., LL.B., B. Sc.; George Rixworthy De Wilde, Esq.; Henry Tilston Hodgson, Esq., M.A.; Richard Stephen Hulbert, Esq.; Edwin James Layton, Esq.; Robert Macgillivray, Esq.; Hugh B. Price, Esq.; and Arthur Thompson, Esq.

The following Paper was read:—

On the Valley of the Vézère, Périgord, its Limestones, Caves, and Pre-Historic Remains.

By Professor T. Rupert Jones, F.R.S., F.G.S.*

Geography.—The River Vézère rises in the Department Corrêze, west of Puy de Dôme, traverses the Department Dordogne, and joins the Dordogne River near Sarlat; the latter river running into the estuary of the Gironde near Bordeaux. The country was a part of the old Aquitania, and subsequently of Périgord.

Geology.—The Vézère rises in hills of metamorphic rocks—gneiss, mica-schist, &c., with quartz veins, a part of the old central plateau of France. Some patches of Coal Measures, and a fringe of red sandstone, are succeeded westward by Rhætic and Jurassic rocks; and at about the eastern limit of the Department Dordogne the river begins to run over almost horizontal Cretaceous rocks, which it traverses nearly to its junction with the Dordogne; thence to the coast the land is formed mainly of Tertiary strata. At Condat, where the railway traveller descends upon the valley of the Vézère, there is a well-known hill of Jurassic limestone, which presents an old cave called "Badegoul." Further down the river the banks present nearly vertical sides, fluted with deep horizontal channels, excavated by frost and water in the softer bands of the Cretaceous limestones. The hard ledges at some places have served as terraces and galleries of rock-hewn dwellings, even large chateaux. Frequently caves, or rather large recesses, have been

* The paper was illustrated by specimens, casts, maps, and drawings, which were described and commented on at large.

found to contain heaps of fragmentary bones and antlers, worked flint implements, carved horns, &c., mixed with charcoal and hearth-stuff, together with the limestone *débris* of the roofs, and occasional human bones. In some instances, below these evidences of human habitation, the bones of an older race of animals, such as elephant, rhinoceros, lion, hyæna, bear, &c., have been found in the earliest deposits in the cave. The animals found in the human accumulations are reindeer, red deer, megaceros, horse, ox, bison, musk-ox, saïga, ibex, chamois, wolf, fox, hare, rabbit, marmot, &c.

Caves.—Of the several caves, Le Moustier, near Montignac, is considered to present some of the oldest types of the implements used by the cave-folk. At the caves known as La Madelaine, Laugerie (Haute et Basse), Cro-Magnon, and Les Eyzies, besides a great variety of stone and bone implements, numerous noticeable carvings, and etchings on stone and bone have been discovered.

Man.—At La Madelaine a skeleton, apparently crushed by *débris* from the roof, has been discovered. At Laugerie and Les Eyzies occasional bones have been found; and at Cro-Magnon a skeleton and scattered bones of three or four individuals were found, as in a place of sepulture, in the inmost recesses of the cave, on the topmost layer of deposits, consisting of *débris* from the limestone roof, intercalated with successive layers of hearth-stuff and ashes.

Within this sepulture were found stone implements, bones, ivory ornaments, and shells, mostly similar to those found in the lowest accumulations of hearth-stuff, of which there were five in succession in this cave, the results of repeated visits of the cave-folk, alternating with bands of material which had fallen from the roof during long ages. The best skeleton was that of a large old man, 7ft. high, with a very well-proportioned head. He was probably a giant and a chief in his tribe. His own familiar flint dagger was by his side. The other bones represented some men and a woman, of ordinary stature, but of the same type. The woman's skull presented a cut, made probably by a flint weapon, but the healing process in the bone had advanced sufficiently to enable surgeons to say that she had survived the injury several days.

A noticeable peculiarity in the bones of these people is the flattened or thin-edged character (*platycnemic*) of some of the limb bones, such as is observed in ancient man from Gibraltar, and from

Denbighshire, and to some extent in the existing negro. Their faces also presented peculiarities, somewhat like those of the Laps and Finns.

Age.—Whether the archaic Aquitanians got the material for their ivory ornaments from elephants slain by them, or met with it in a semi-fossil state, some perhaps may find room for discussion; but that they were really acquainted with the hairy elephant or mammoth there is full evidence; for they have left a lively outline of this peculiar and shaggy animal on a piece of ivory at La Madelaine, and a carved head, as an ornament, at Laugerie. Their neighbours, too, who lived at Bruniquel, in the Departement Tarn et Garonne, knew the same animal well enough to carve a poignard handle in its shape. The extinction of the mammoth by altered conditions of the country, even when aided by weapons and pitfalls, must have taken a long period, and is associated with territorial changes, such as the separation of the British Isles, resulting from slow processes.

The abundance of reindeer co-existing with the Perigordian cave-folk indicates the concurrence of a cold climate in southern France. That the reindeer were hunted only, and that during their seasonal migration, seems probable, though the enormous number of slain reindeer, of all ages, would seem at first sight to indicate that they were always at hand.

The caves would be nearly uninhabitable in such summers as now obtain in France on account of the heat, especially if the constant supply of game, and the accumulation of animal refuse, be taken into consideration.

What terrestrial or cosmical conditions in past ages gave the required conditions for the climate under which these old cave-folks existed, we do not know. That this cold condition of Southern France ceased long before the Roman Invasion of Gaul there can be no doubt, although the reindeer is passingly referred to by Cæsar in connection with the Hercynian Forest. How long a time was required for the changes in land and sea, mountain and valley, for the change from a Glacial to a Boreal and Pluvial climate, with its ever recurring snow and rain, excavating the higher valleys and filling up the coast valleys with enormous accumulations of sands and gravel, we have but few means of calculation to judge by. The criteria presented to geologists in the changes of relative level of land and sea, in the excavation of valleys, and in the accumu-

lation of deltas, may lead us to date the existence of Périgord cave-folk at not less than some 9,000 or 10,000 years ago.

P.S.—For details and illustrations of facts and specimens the Author referred his hearers to the "Reliquiæ Aquitanicæ, or Contributions to the Archæology and Palæontology of Périgord and the adjoining Provinces of Southern France," by E. Lartet and H. Christy, edited by T. Rupert Jones, F.R.S., in parts, 4to., Williams and Norgate, London, 1865-1873.

EXCURSION TO AYLESBURY.

MAY 5TH, 1873.

Director—Professor MORRIS, F.G.S.

Though the famous Vale of Aylesbury is on the Kimmeridge Clay and Gault, the town of Aylesbury stands on a boss of Portlandian age, rising above a surrounding of Kimmeridge Clay, which extends north-eastwards and south-westwards, and forms the country to the north-west for six or seven miles, except where beds of alluvial deposits form low-lying meadows, through which sluggish streams meander. One of these, and the most considerable, patches of river deposits lies immediately on the south-west of Aylesbury, and is crossed by the road to Oxford, which continues in a general south-west direction, crossing in succession, after the fluvial beds, the Kimmeridge Clay, the Portland Sands, the Portland Stone, the Purbeck Beds, and the Lower Greensand, thus giving a "gathering section." The party of Members, headed by Professor Morris, on arriving at Aylesbury, accordingly proceeded along this road, crossing the patch of valley gravels, and stopping at a large excavation at the junction of these beds with the Kimmeridge Clay, which is here worked for brick and tile making. The clay possesses its normal character, and is fossiliferous, *Ammonites biplex*, *Thracia depressa*, *Ostrea deltoidea*, and *Astarte Hartwellensis* occurring here in considerable abundance. The clay is largely impregnated with iron pyrites, with which most of the ammonites are richly encrusted.

The Portland Sands form a narrow fringe to the Portland Stone, which underlies a large area in the district, and is extensively quarried for the fine building stone which this formation invariably yields.

Passing Hartwell House, formerly the residence of Dr. Lee, a well-known friend of London Geologists, and of whose scientific tastes the many large ammonites (*Ammonites giganteus*) built into the park wall are memorials, the party proceeded to the quarries, on the road to the village of Stone. Here is exhibited a fine section of the Portland Stone, with Purbeck Beds forming the upper strata.

Cardium dissimile is abundant and *Ostrea falcata* by no means uncommon, while the many fine specimens of *Ammonites giganteus* before-mentioned as studding the wall of Hartwell Park, testify to the frequency with which that large species is found in this locality.

Nearer still to the village of Stone, a bed of fine white sand of probably Neocomian age, and worked for glass-sand, is met with. It contains large concretions of siliceous matter, which assume, in some instances, very curious forms.

The route was continued through Stone to the south-west, until an xposure of Purbeck strata arrested the attention of the Members, who found the rock which is quarried here to be full of the casts of cyprides. The party then returned to the town of Aylesbury, where the train was taken for London. At each section visited during the day, Professor Morris described in detail the beds exposed, their extension in the district, and the physical geology of the surrounding country.

EXCURSION TO EASTBOURNE AND ST. LEONARDS.

MAY 23RD AND 24TH, 1873.

Directors.—The Rev. E. S. DEWICK, M.A., F.G.S.; JOHN HOPKINSON, Esq., F.G.S.; and J. E. H. PEYTON, Esq., F.G.S.

(Report by Mr. Hopkinson.)

On their arrival at Eastbourne the Members were met by the Directors of the Excursion and at once proceeded to the Eastbourne College, to inspect the collection of local fossils in the College Museum. This collection has been formed within the last few years by Mr. Dewick, who pointed out some of the more remarkable specimens, and gave a brief account of the succession of the beds in which they had been found. After paying a short visit to

Dr. Ogier Ward's fine collection of fossils, the Members visited the Caldecott Museum, where they were received by F. C. S. Roper, Esq., F.L.S., F.G.S., and C. J. Muller, Esq., two of the Trustees. There is here preserved an extensive collection of local fossils, a small typical collection of the fossils of other localities, and specimens illustrative of the recent botany and zoology of the neighbourhood (terrestrial and marine), &c., arranged and classified by various members of the Eastbourne Natural History Society. Mr. Roper, who is now President of the Society, then very kindly entertained the party at luncheon, at his residence, Palgrave House.

After luncheon the excavation for the new baths at "The Wish" was inspected. Here an alluvial deposit, containing land and freshwater shells, antlers of the red and roe-deer, and remains of the wolf, horse, ox, and pig, is seen to overlie the Gault.

The fine cliff-section of Upper Cretaceous rocks exposed between the Wish and Beachy Head was next examined. The lowest bed seen is the Gault, which is brought up by an anticlinal under the Wish Tower (Martello Tower, No. 74), a small portion only, almost unfossiliferous, being exposed. The Upper Greensand, or Chloritic Series, with phosphatic nodules, and fossils only in its upper layers, is next seen. Here it is 30 feet thick, but it thins out to about 20 feet at Beachy Head. The Greensand, a grey calcareous sandstone, gradually becomes lighter in colour and more calcareous as it passes into the Chalk Marl, which is here very fossiliferous, having a bed of calcareous sponges at its base, then several bands of ammonites, and other fossils in its higher zones.

In the extensive quarries in the Middle Chalk at Holywell, several fossils, including some fine so-called "palatal" teeth of *Ptychodus*, were obtained. Here a descent was again made to the shore ; and in continuing the walk under the cliff to Beachy Head, the numerous faults and slickensided surfaces of the chalk, the anticlinal near Cow Gap (which again brings up the Gault and Upper Greensand, the latter here much more fossiliferous than at the Wish), and the landslip which obscures the greater part of this anticlinal, were especially noticed ; and at the farthest point reached were collected specimens of Polyzoa and Echinodermata, which abound in the lowest zone of the Upper Chalk, here forming an almost perpendicular cliff about 500 feet in height.

The party then returned to Eastbourne by the path along the edge of the cliff, and in the evening attended a meeting of the

Eastbourne Natural History Society, at which Mr. Dewick read a paper "On the Alluvial Beds of the Wish," preceded by a brief general account of the geology of Eastbourne.

On Saturday morning the Members left Eastbourne for St. Leonards. On their arrival at the station they were met by Mr. Peyton, who had most kindly provided carriages for the day. The Old Roar quarry, an extensive excavation in the Wadhurst Clay, was first visited. Here, a bone-bed, almost entirely made up of the teeth and bones of the old Wealden reptiles and fishes, is exposed. It appears to have formed the bed of a river, and may at one time have been continuous with the similar bed exposed at the Black Horse quarry, near Battle.* Overlying the bone-bed a leaf-bed containing impressions of ferns is seen; and below it the Wadhurst Clay encloses a bed of stone, a concretionary argillaceous limestone from three to four feet thick, for which the quarry is worked. Below this is a bed of blue clay, and then another bed of stone, the whole reposing on the Ashdown Sand. Two other quarries, one in the upper part of the Ashdown Sand, the other in the Wadhurst Clay, were then visited, and in each of them numerous fossils were found.

The beautiful glen of Old Roar especially attracted the attention of the geologists. The stream runs along a fault, and the glen most probably owes its existence to the convergence at this spot of three lines of fault. At Silverhill a fine section of the Tunbridge Wells Sand was observed; and on the return to St. Leonards the party had an opportunity of observing sections of each of the beds of which the Wealden Series is composed. In descending order these are:—Weald Clay, Tunbridge Wells Sand, Wadhurst Clay, Ashdown Sand, and Ashburnham Beds,† the last named being probably the equivalents of the Upper Purbeck Beds of Dorsetshire. The Members were then hospitably entertained at dinner by Mr. Peyton at his residence on the Marina.

After dinner the party proceeded westward towards Bexhill. The fault by which the Ashdown Sand is let down against the

* I am informed that this bone-bed, which I examined some years ago, is not now to be seen.

† Mr. Peyton informs me that since this excursion took place the Geological Survey has re-named the Ashburnham Beds the "Fairlight Clays," and that "the limestone and shale beds of Rounden Wood, Archer's Hill, Netherfield, &c., which used to be called the 'greys' and 'blues' of the Ashburnham, are now marked as Purbeck," this being settled by the discovery of the gypsum at the Netherfield boring.

Ashburnham Beds was observed at Bo-Peep Station; and the "submerged forest" between Bo-Peep and Bulverhithe, which can only be seen when the tide is at its lowest, was next visited. Here remains of oak, yew, hazel, and other trees, in their natural position, were seen, and a few hazel nuts, &c., were collected. On the shore the Ashdown Sand, the mottled clays of the Ashburnham Beds, &c., were successively passed over, and in the Bulverhithe and Bexhill cliffs fine sections of these beds were observed. They are very difficult to work out, owing to the numerous faults which traverse them in all directions. Numerous specimens of an *Estheria* were obtained from the Ashdown Sand. In a single zone less than a foot thick this little Crustacean is especially abundant.

We are now under Tower No. 44, which stands on the very edge of a lofty overhanging cliff of the Ashburnham clays and sandstones. The mottled clays of the Ashburnham Beds are seen on the shore at low-water, passing upwards into sandstone in distinctly bedded layers, thin seams of lignite being here and there exposed; and just at the top of the cliff repose the Ashdown Sands, supporting one of England's old, now useless, defences, which at no distant date will become a prey to the ever advancing waves.

At Bexhill tea was kindly provided by Mr. Dewick, and the Members separated at the station for their respective destinations, having spent a most enjoyable time in exploring the Wealden and Cretaceous Rocks of Eastbourne and St. Leonards.

EXCURSION TO FINCHLEY.

MAY 31ST, 1873.

Director—HENRY WALKER, Esq., F.G.S.

(*Report by Mr. Walker.*)

A large party of the Members and their friends assembled at King's Cross Station, Great Northern Railway, and took the train for East End. At East End Station the company retraced their route for a short distance, and stood on the lofty railway embankment over the valley traversed by Mutton Brook, in order to survey the geographical features of the Finchley district in so far as those features have been determined by the Glacial Beds. By the aid of

an enlarged copy of part of the Geological Survey Map of Middlesex (Superficial Deposits), the Finchley Glacial District was seen forming a roughly triangular plateau. The base of the triangle runs nearly due east and west—from Muswell Hill nearly to Hendon—whilst the apex is found near East Barnet. The base and west side of the plateau were seen to be bounded by well-marked valleys, which define the limits of the Glacial Beds and tell of the meteoric agencies which have helped to reduce them to their present limits. These features having been studied, the party descended the embankment, crossed the valley, and entered upon Glacial ground, each Member being presented with a copy of the enlarged map already described. After a pleasant walk along a rural highway, over-arched by the whitebeam, and lit up with the gay corymbs of the horse-chestnut, a pause was made at Marylebone Cemetery. Here at the lodge-gates, and decking the ornamental rock-work, were seen a number of the characteristic Drift fossils of the district, especially gryphæas, belemnites, and ammonites, which are yielded plentifully from the Chalky Boulder Clay at this spot. By permission of the Superintendent of the Cemetery, the collection was inspected by the visitors. The excursion was then continued past the Manor House moat and pond, through pleasant green fields, across the Edgware and Highgate Railway to the Manor Brickfield, Finchley. Here, by the courtesy of Mr. Charles Plowman, the proprietor, some interesting sections were open to inspection. Mr. Walker then proceeded to explain the nature and review the history of the exposed deposit—the Great Chalky Boulder Clay of the South-East of England. The accumulations at this spot belong to the period of the great submergence of England beneath the Glacial sea, and are not the immediate products of land ice. The relation of the Finchley and Muswell Hill Glacial Beds to the Essex outliers of the same deposits were then exhibited, Mr. Searles V. Wood, jun., F.G.S., having kindly forwarded to Mr. Walker his Drift Map of Essex for this purpose, as well as numerous sections across the Valley of the Lea, showing the former connection of the deposits now divided by that valley. At the conclusion of the address a collection of fossils obtained by Mr. Plowman from the pit in which the company were assembled was exhibited by that gentleman; after which the Members themselves made a successful search, many fossils from the Oxford Clay, Lias, Oolite, and Chalk being

discovered, as well as rocks of great variety, including striated chalk pebbles and boulders, *in situ*. The party subsequently proceeded to the higher ground, near Finchley Station, facing Mill Hill, where Mr. Caleb Evans described the physical features of the country, and exhibited sections illustrative of the range and outcrop of the various local formations.

ORDINARY MEETING, JUNE 6th, 1873.

ROBERT ETHERIDGE, Esq., F.R.S., F.G.S., &c., Vice-President, in the Chair.

The following Donations were announced :—

"Forekomster af Kise i visse Skiffere i Norge," by E. B. Münster ; from the Author.

"On Irondjems Stifts Geologi," by T. Kjerulf; from the Author.

"A First Book of Mineralogy," by J. M. Collins, F.G.S.; from the Author.

"A First Book on Mining and Quarrying," by J. M. Collins, F.G.S. ; from the Author.

"The Palæolithic Age Examined," by N. Whiteley, C.E. ; from the Author.

"On the Rise of Land in Scandinavia," by S. A. Sexe.

"Hymn in Praise of His Majesty King Charles of Norway;" from the University of Christiana.

"King Coal's Levee ; or, Geological Etiquette;" from George Potter, Esq., F.R.M.S.

"Further Notes on the Punfield Section," by C. J. A. Meÿer, F.G.S. ; from the Author.

"Abstracts of the Proceedings of the Geological Society;" from that Society.

"Catalogue of the published Maps, Sections, Memoirs, and other Publications of the Geological Survey of the United Kingdom" (three copies).

"Journal of the Quekett Microscopical Club;" from that Club.

"Quarterly Journal of the Geological Society;" from that Society.

"Proceedings of the Literary and Philosophical Society of Liverpool;" from that Society.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club, 1872;" from that Club.

"Communications to the Monthly Meetings of the Yorkshire Philosophical Society, 1872;" from that Society.

The following were elected Members of the Association:—

Professor William Henry Flower, F.R.S., F.L.S., F.G.S., &c.; James Griffin, Esq., M.R.C.S.; and Mrs. Emily Parker.

The following Paper was read:—

On Ammonite Zones in the Isle of Thanet.

By Francis Alfred Bedwell, Esq., M.A., F.R.M.S.

It has been suggested to me that it would be acceptable to the Association if I were to lay before it certain particulars obtained in the course of the last three years respecting a bed of Ammonites which is to be found in the Chalk at Margate. Unfortunately, the details which I took of the bed at the time when I made the observations were recorded in a very unsystematic manner, and without the least idea that any character of novelty attached to them which rendered them worth preserving, or that I was being made acquainted with facts which were outside books, or which, in consequence, were likely to prove interesting to scientific men. It is always so very difficult for any student to believe that in anything which he discovers for himself he is beholding something that is really new; something that is not already recorded.

Unfortunately, too, I cannot lay any claim to the character of being even a systematic student of geology. I can only ask to be received in our Association as a mere inquirer or scientific adventurer, who, from want of knowledge, feels wholly unequal to describing in appropriate scientific language the facts which he has been requested now to narrate. It is with the utmost sincerity, therefore, that I apologise for employing in my narrative my own informal language. My plea is that I know no other, and that if I were to attempt to adopt the language of precision I should be simply taking up weapons and putting on armour which I had never proved, and of which I do not know the use.

Some apology also is necessary for my venturing to address the Association at all, but I stand, in fact, before you somewhat in the

character of a forlorn hope. It has been long felt that the younger and the less advanced Members of the society, the student class, through want of confidence, abstain from holding that position in the discussions of the Association which, when the society was originally formed, it was particularly hoped that they would occupy; and in acceding to the request made to me to compile the present paper, I have had specially in view the hope that my temerity in thus coming forward with a so-called original paper (temerity which I am in no way disposed to underrate) may induce other Members of the Association who have hitherto been deterred from entering personally into the discussions which take place at our meetings to abstain for the future from their bad habit of silence, and to add their voices more frequently to the general flow of conversation which ought to follow every paper that is read amongst us.

The existence in the Flint-bearing part of the Chalk, and notably at Margate, of ammonites of considerable dimensions appears to have been one of those waifs and strays of geological information which perpetually dance before the eyes of the student as amongst the notorious facts which everybody knows, and which yet when followed up elude the grasp with tantalizing and provoking rapidity. It is just one of those little bits of knowledge which are so often consigned to notes in scientific books, and given to the reader without reference to any particular authority which he can trace to its source. I found that many geologists spoke so familiarly about the large Margate Ammonites, and treated them as being so well known and common, that when I reached Margate for the first time, which I did three years ago, I actually expected to see these molluscous marvels lying scattered promiscuously about on the cliffs and on the rocks as plentifully as whelks, and as easy to find as periwinkles. I need hardly say that my disappointment was considerable when I found that the very contrary was the case, and that notwithstanding search upon search, yet that day after day passed and I could find no single specimen either on the cliff or on the shore. Now, there is nothing more humiliating to the student mind than to find itself contemplating a cliff side in which a properly-trained eye sees at a glance fossils by the scores, where the student's unschooled vision can see nothing but chalk and rust and flints—flints and rust and chalk succeeding each other in endless and monotonous profusion. But if the student is easily daunted,

he is also easily pleased, and one very fortunate day, when I was on the point of abandoning the search for ever in despair, I found the long-sought prize, and found at a height of about 20 feet above me, embedded in the cliff, the under side of the chalk-cast of a gigantic monster. There was the graceful outline of the coiled-up disc—there with all its beautiful foliage lay that pattern which I had hitherto only seen in the pages of Buckland—the lovely tracery of the leafy sutures in all its elegant intricacy, yet perfect regularity. To those students of nature who can remember the joy which they derived from the discovery in some lovely tide pool of their first tiny little microscopic zoophyte—to those who can recall the first impressions which the first view of any special gem, and above all, the first "unaided" recognition of any of God's masterpieces afforded them—it will sound no exaggeration to say that that moment was one of unspeakable satisfaction to the spectator—satisfaction which was all the more enhanced by the preceding disappointment. I may say, that as the result of a three weeks' search it seemed at first impossible that this could be otherwise than an isolated specimen; but I was not long in abandoning such an ill-founded idea, and soon became convinced, by a process of reasoning not very difficult to follow, that it must necessarily have had relatives of some kind—a father, a mother, to say the least of it, besides brothers and sisters, and, in fact, "next of kin" generally, and that therefore somewhere in the neighbourhood I might reasonably expect, with properly trained eyes, to find a few of his family connections and friends. Again, accordingly, I renewed my search, and once more without the slightest success. My eyes wandered all over the cliff, but ineffectually; I could find no more, and, with a single trophy in my possession, I left Margate.

In the autumn of 1871 I had opportunities of renewing the search, and in the interval my attendance at these evenings, and, above all, a perusal of Mr. Caleb Evans's admirable and most systematic paper on the Caterham Chalk, opened my eyes to the possible existence in the Cretaceous System of specific "zones" of life, possible zones or horizontal beds of fossils—that is to say, if I understand the expression aright—which represent specific successive periods in which certain specimens of life found in the Chalk may be said to have been at a "maximum," and accordingly I assailed the Cliff again from this point of view, and looked about for an Ammonitic Zone or bed.

I need hardly point out that before I could begin such a search it was necessary to decide what was the true plane of the horizon of the ancient Chalk Sea ; in other words, to make out the parallel lines of its successive sea floors. Now, as is well known, the Chalk immediately to the east and west of Margate is almost entirely free from flints ; it becomes, therefore, exceedingly difficult to follow the movements of the strata in their various undulations, to trace, that is to say, the periodic variations in, and lines of accession to, the flooring of the Chalk Ocean.

As I am quite ignorant what propositions I may assume in a paper of this kind, and what propositions I must give a reason for, I will here add that I assumed, for the purpose of deciding the horizon I was in search of, that it was parallel to the lines of flints which I found in the Chalk of the island ; all of which, being virtually parallel to each other, must have been parallel, as it seemed to me, to some one connecting line, and what line that could be except the floor of the ancient Chalk Sea I could not, and cannot now, imagine. Most fortunately in this almost flintless strata I found, 8 or 10 feet above the ammonite which I had already recognised, that there was exhibited a very faint bed of flints very difficult at times to decipher, but sustained with absolute regularity along the face of the cliffs in the places in which it is visible. I thereupon seized this bed as a guide, and followed it, and kept the eye watching a line in the Chalk lying at a distance of 8 to 10 feet below it. By doing so, I found in a few days, embedded in the face of the Cliff, one after another in succession, fragments of four ammonites, all apparently of great magnitude, every one of which was lying in a bed or zone parallel to the line of flints which I had thus taken for a pioneer ; each of which I could touch with my hand, and each of which I had in the previous year passed by over and over again without ever noticing any single one of them. I was like the man in the Eastern story, whose eyes were touched by the precious spikenard, and who in a moment saw all the treasures of the mountains revealed to him ; I was like a blind man made to see. It was, in fact, the " zone of life " theory that found the ammonites for me, and without its help my unaided vision might have searched till now, and I should probably have had but that one specimen to repay me for my pains.

Having thus exhausted, as I supposed, the Eastern side of Margate, in a search for specimens, I followed up the search along the face of the Cliffs to the Westward—and there, again, I found a

weak, solitary line of flints, and, in the hope that it might prove to be the guiding line which had directed me on the previous search, I accepted it as such, and, following it closely, found, to my infinite satisfaction, two more ammonites which lay in such positions that (presuming the lines of flint in each cliff to be in continuation)* they represent a bed of ammonites precisely identical in its attitude relatively to the line of flints with that which I had found on the eastern part of the shore.

But the personal part of my narrative is not quite complete. I went to Margate, three weeks ago, in order to verify the facts I have just stated, and, strange to say, when I reached the bed in question I actually found in the Eastern Cliff, and, in less than an hour as I walked hastily along the beach, not only every one of my old friends, but eight new ones, all of which had escaped my uneducated eye on previous occasions, everyone of which was in the bed in question, everyone of which lies horizontally, and most of which vie in magnitude with those previously found, and running from 3 to 4 feet in diameter, and the eight thus recognized form, with the five found previously, a group of 13 ammonites situate within half-a-mile of each other, and all, with a few exceptions, which I have not had time† hitherto to distinguish, lying accurately in a line, which, to the best of my belief, may be traced and covered by a thread‡ or string kept strictly parallel to the line of flints, 8 feet above it, already referred to; in other words, in a plane coinciding with the sea floor of the Chalk Ocean for the time being.

Unfortunately on this, the last occasion, when I visited the spot I was prevented by the tide from taking down the particulars respecting these new specimens, which I should like to have brought away for your satisfaction, and which the subject certainly deserves, and these are particulars which I must reserve for future investigation.§ In self-defence, and lest the students amongst us should go away with the impression that I was unusually dull in occupying so long a time over what sounds rather

* As I have since discovered that they are.

† This has since been done, and I have taken exact measurement of each. See reference, "Geol. Mag." below.

‡ This proves to be approximatingly accurate only, but it is strictly accurate as to four of the specimens, which lie within about 50 yards of each other, and all in the same plane.

§ I have since made these observations, and the details will be found—"Geol. Mag.," Dec. 2., Vol. i., January, 1874.

simple to tell, and looks exceedingly simple when it is shewn to you at the cliff-side, I may add this, I gave two friends, independently, all the particulars I could of the bed by description, and they could not find a single trace of it, while, on the other hand, on my last visit, I showed a gentleman and a lady on the sands, as they stood wondering what I was gazing at, a very large specimen which I had just found, and I pointed out to them the line in which they should look for more, and, though they had evidently never before seen anything of the kind, they went on in advance of me and found two magnificent specimens, one after the other, with the greatest ease.

It is really impossible to do justice to the satisfaction which the mind feels when it has had the good fortune to fall into such a track of circumstances as that now described, or to explain the rich store of ideas which come crowding in upon the imagination at such a time, and as one after the other each fresh specimen is observed.

The spectator seemed to appreciate in a moment, and for the first time, the actual reality of the sea-bed into which these decayed marvels fell so softly and died. It was as if one stood alone at the bottom of that mighty ocean, viewing these great discs, with their weird, unsightly freights, fall slowly one after another in the dim twilight of that deep, silent sea, and beheld each one reach its soft, white powdery bed, and then turn gently over on its side, perchance to move no more and then—and as the ideas of a hearer are always in advance of a reader, so you will doubtless already have anticipated—came the thought that this was not only a zone, an horizon "of life," but was also, and it may be will have to be, more appropriately called an horizon "of death."

I saw enough of the bed to convince myself that it will be a very difficult task indeed to disprove the proposition, which at once suggests itself to the mind, that this must have been a case of "migration," and was not the case of a localised body of ammonites, dying in a sea in which they had always lived. They seem to appear and to disappear simultaneously, and in one line or plane; the moment that you find that line or plane there you find the ammonites; till you find that line—or if you fail to find that line—you fail to find them.

Out of the whole 13 there are only one or two of which I can at present say positively that I think they lie in a different plane from that of their companions, and as to the exceptions, it is quite

possible that it may turn out upon closer inspection that the more elevated position may be due to some special local pressure in that particular part of the strata. As the eye travels upwards in the Chalk in its search for signs of vitality, it is quite suddenly arrested, as it were, by this line of life. It comes upon 13 specimens of a kind of animal of which it has found no trace whatever till it reaches this line; it is this "unanimity" about their appearance that so strongly suggests the idea of migration.

Again some of them appear to be in close proximity with each other, three of them actually lying almost touching each other; so that whatever you may think when you hear it described, yet when you come to see the bed with your own eyes—if you ever do so—you will arrive, at any rate at first sight, at the instant conclusion, not only that all the specimens, or certainly the large majority of them, must have reached the spot together, but that they also died together, or, as it were, unanimously, and that whatever may have been the occasion of the catastrophe, yet that it *is* the result of a catastrophe that you are examining, and that, in fact, a common cause affected them all at one and the same time, and laid them where we now see them. For just as the unanimity of their appearance suggests the idea of "migration," so the unanimity of their disappearance equally suggests the idea of a catastrophe.

This, I say, is the *first* impression; on second thoughts, however, we find that there is an element which has to be considered, and which when allowed to have its due weight may somewhat modify our first impressions. That element is *time;* the amount of time, that is to say, which was expended in accumulating at the bottom of the ocean a sufficient amount of deposit to alter and raise the sea bed, say to the depth of an inch, so as to make a difference in level visible to our eyes of that thickness of strata; in other words, the amount of time which it took to form the Chalk. Now, supposing that it took, say for argument's sake, a million of years to accumulate at the bottom of the sea the solid rock which we call the Chalk, why, then, when you come to divide that period of time over the whole formation, you will find that you have something, say between 600 to 1000 years, for the accumulation of each foot of chalk; or say between 50 and 90 years for every perpendicular inch, and in that case these ammonites may have every one of them lived quite a long life, and yet when they

died have fallen on what, when it is pressed down and converted into a solid rock, will look to our eyes exactly like the same bed for each ammonite.*

For myself it seems to me, if I may venture to say it, that a million years is by no means a long period to name for the expenditure of vital energy necessary to elaborate in nature's laboratory such a mass of matter as the Chalk, and that when we consider that the whole of the rock which we now call by that name must have been once held in solution by the waters of the ocean, and must then have been converted first into vegetable† forms of life, and then into animal forms of life, and after passing through these stages over and over again ended in the impalpable powder of minute ejectamenta, or minute tests of a microscopic animal—each minute separate particle being, in fact, a separately prepared stone in the mighty edifice—I confess the mind stands altogether awestruck at the thought of the vast sweep of time that seems to be required for such operations; it fails to estimate the amount of laborious hours needed for the purpose, and finds a million years all too short a period for so marvellous an undertaking.

But there is evidence of another Ammonite Bed in the Isle of Thanet. I shewed my specimens to a very intelligent gentleman at Margate, Mr. Stodart, a photographer, and in return he described to me an ammonite which he had seen when a boy upwards of twenty years back, and it lay, he told me, on the chalk of the beach itself, and it will show how wonderfully slow is the action of the sea on the flat portions of a Chalk shore, when I mention that I followed his directions, and found the ammonite exactly where he described it—very rough and very much worn, but in-

* It will be found on reference to the "Geological Magazine" above cited that this second view is correct; the zone is at least 50 feet thick, runs through the island, and the specimens mentioned in the present paper prove to be the representatives of a line of maximum development of life within the limits of the zone and at the upper part of it.

† It has been suggested that some foraminifera take in their "chemical food" direct, and without the intervention of vegetable intermediants at all. If so, how is it that these fortunate animals do not surpass all others in the struggle of existence, and destroy every other form of life? The same observation applies to those equally fortunate products of spontaneous exhibitions of nature's life-giving powers—those happy results of the fortuitous adventures of inorganic atoms of which we hear so much now. What chance has an "egg or seed-born" animal with them in the struggle for life? Indeed, why with all their apparent opportunities of becoming organic, do any inorganic atoms that *can* come to life ever fail to do so, or ever appear in any other than an organic form? Nature never harasses them by a bath of sulphuric acid succeeded by a temperature of over 200° Fahr., and yet that treatment is alleged to have no effect upon the ultimate result. If it is inorganic matter $+ x$ which we are talking about, one can answer the question; but if $x = o$, I see no way out of the difficulty.

FIGURES TO ILLUSTRATE MR. BEDWELL'S PAPER ON AMMONITE ZONES.

Fig. 1.—Outline of Isle of Thanet.

WEST.

FIG. 2.—Cliff-section from Birchington to Kingsgate.

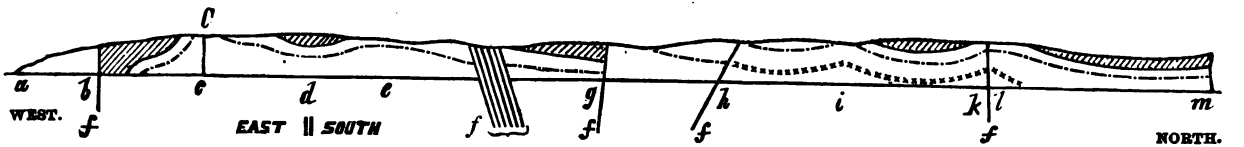


FIG. 3.—Cliff-section from Kingsgate to Pegwell.

EXPLANATION OF FIGURES.

FIG. 1.—Sketch-map of Isle of Thanet.
FIG. 2.—Cliff Section from Birchington to Kingsgate.
FIG. 3.—Cliff Section from Kingsgate to Pegwell.

The shaded part represents the Ammonite Bed, bounded on the upper edge by the guiding line of flints, as identified since the Paper was read.

– – – – – – – – – – – – – – – – The Three-inch band of flints.

a. Tertiary Beds.
b. Pegwell fault at which Tertiaries begin.
c. A point a little east of Landing-stage, Pegwell. Lowest point of Chalk.
d. West Cliff Terrace.
e. Ramsgate Harbour.
f. Various faults.
g. Dumpton Stairs.
h. Dumpton Point.
i. Broadstairs.
k. Stone Stairs.
l. North Foreland.
m. Joss Stairs.
n. White Ness.
o. Fore Ness.
p. First Gangway, east of large Flagstaff.
q. Jetty-end of Cliff, Margate.
P. Explained in text.
r. Infirmary end of Cliff, Margate.
s. Marsh Bay.
t. Apple Bay.
u. Birchington.

stantly distinguishable. This specimen lay about 40 feet below the line of those mentioned above, and subject to the full force of the waves at high water.

The only traces which I have been able to find in the Books of beds in the Chalk in which the size and characters of the ammonite are at all similar to the details of those to which I have now called attention are the following:—1st. At Brighton, in Lower Chalk, or chalk which is very near the Lower Chalk; it is Chalk with flints. 2nd. At Lewes, also, in the Lower Chalk. 3rd. At Beachy Head, in chalk which I do not find identified. 4th. At Dover, in chalk which, I presume, ought to be called Middle Chalk, and which, at any rate, is Chalk with flints, and which succeeds Chalk without flints.* 5th. Selbourne, in Hampshire. 6th. Croydon and Caterham.

If there are in England any other beds of such large ammonites in the Chalk referred to in scientific books, they have escaped my notice.

The Chalk between Margate and Dover has been divided by Professor Phillips and Mr. Whitaker in their well-known papers and works on the subject, and I would venture to supplement their respective views by calling attention to a stratigraphical circumstance in connection with the flint in this part of the Chalk strata of England, which I cannot help fancying is of some importance.

I will first describe the diagrams attached to this paper. The point *p* gives the position of the ammonite which I first found. The black line which forms the upper margin of the shaded part of the cliff in the perpendicular sections represents the line of flints which I took for my guide; and about 10 feet below it, between *p* and *q*, lies the bed of ammonites, with the thirteen specimens which I found, as above described; at a point about half way between *p* and *q*, is a gangway which leads up to the Coast Guard Station, near to the Cliftonville Hotel, and beyond this point I have not at present† been able to find any indication of the bed till we get much further to the west, but I feel no sort of doubt whatever that the indications do exist, and that the bed cannot possibly end

* I hope to be able hereafter to shew that these four beds are really all identical; if so, they are separated from the zone discussed in this paper by about 200 or 250 feet of chalk, that is to say, by the chalk forming the cliff between Dover and Old Stairs Bay.

† That is to say, when this paper was read. I have since found many more. See "Geol. Mag.," l. c.

abruptly at the point in question. At the point *r* we get beyond the Harbour to the west of Margate, and there I found the traces of a bed which, as I have said, I believe to be a continuation of the eastward one; and at *r* we see the before-mentioned line of flints again. Skirting the upper part of the cliff, about three parts of the way from *p* to *q*, is the position of the ammonite which Mr. Stodart pointed out to me down in the beach line.

Now, turning back, and walking eastward, we reach at *n* the White Ness point just at the extremity of the first perpendicular section, and here (just before we arrive at *m*), Joss Stairs, lines of flint begin to rise, and at Kingsgate, between *n* and *m*, there springs up a bed of flints from out the sand, to which I must call your very particular attention.

It is a strong and a most determined band of dark rusty flints, sometimes becoming *apparently* nodular; I say apparently, for I believe that it rarely assumes that character at all, but that it is almost throughout its course, where visible, an undeviating mass of solid rock, between three and four inches thick, not tabular, but with undulations and elevations on each surface, very much like those in a flat piece of pie crust. It stands out in marked contrast from every other line of flint in the Island, and it is only broken, or rather pierced here and there at distant intervals by spots in which rings or pockets of chalk, for a short space, destroy its continuity.

When we turn the corner at *m*, Joss Stairs, and begin to walk southward, we fall into the second perpendicular section, and there in continuation will be found the line of flints just mentioned, fluctuating in its movements with the fluctuation of the strata, broken by faults in various places, carried off the cliff in others by denuding forces, but never once reaching the base of the cliff, and always pursuing its way steadily on past Broadstairs, past Ramsgate, till we reach the other angle of the coast at Pegwell Bay, at *d*, where the shore again retires, and here this line of flints quits the cliff altogether, and, after lying flat on the beach for a short distance, ultimately sinks below the shore line, and continues its course* beneath the sea level. From this point, *d* to *b*, a repetition of the strata, seen in the first section, succeeds, and the same soft chalk which is in section at Margate, once more predominates in the cliff side, until the Chalk itself is lost beneath the Tertiary Beds, at the fault at the point *b*. Now it is impossible to follow the

* As to its further course, see "Geological Magazine," l. c.

bed of flints, to which I have called such special attention, right round from Kingsgate, where it first appears, to Pegwell Bay, where it disappears—to notice its undeviating solidity, and its uniform contrast to all other beds of flints above and below it, without coming to the conclusion that in all probability it must underlie the whole Isle of Thanet.

I believe this is not a mere probability, but a certainty. For one day I found, with great satisfaction, that at the point P, at Margate Harbour, about four miles from the spot, between *m* and *n*, where it first appears on the cliff at Kingsgate, it crops up again to the surface, having passed under the shore line in the interval in the direction indicated in the section, and forms, for a few yards, at Margate, as it does at Pegwell, the shore line, while it has been pierced at this point, P, to admit of the foundations of the stone embankment, which backs Margate Harbour, being laid through and below it.

Further I made enquiry as to its inland movements of two well diggers, and they both knew the band as being one which met them everywhere on the Island wherever they dug wells; "you must break though it with the crowbar," they said, "for you cannot pick it up; you may pick up every other band in the Island, but this one you must break through;" and one of them added the characteristic observation, "that he knew it well, for he had many a time broken his knuckles against it." One of them pointed out Haine as a place where he had dug a well, and remembered piercing it, and he informed me that at Westgate, point *s*, he went through 70 feet of soil without reaching it, but he heard the water beneath his feet running like a stream at the lowest point of the well, and he attributed this circumstance to the bed in question, which made a solid floor beneath which the water could not pass.

Here then is evidence of flint manufacture, so to speak, on a large scale, which, for its definiteness and certainty, I fancy is almost unique in England. You have here (undoubted) evidence that the action, whatever it was, which produced the flints at Kingsgate, must have been going on with exactly coincident force all over an area of at least about 20 square miles, and I shall endeavour to shew presently that, in all probability, this area is *a very much* more extensive one still. Such as this band of flints is at Margate, such exactly it is at Kingsgate, at Broadstairs, at Ramsgate and at Pegwell Bay; meet it where you will, you cannot

possibly mistake it, in every attitude it has always the same rigid, inflexible, impenetrable aspect; it is, in fact, like a solid floor of iron plate running through the Island, and this proof of its continuity is a circumstance which, I fancy, will be found by no means without its importance in the bearing which it has generally upon the subject of flint formation in the Chalk.

There is another instance in the Island of continuity of coincident chemical action in a line of yellow chalk noticed by Mr. Whitaker, who by the way also notices the "three-inch band" of flint. This line of yellow chalk rises between White Ness and Kingsgate, and runs parallel to and above the "three-inch band" of flint; it is to be seen at Pegwell Bay, in its appropriate attitude, parallel to the three-inch band, and in appearance similar to the aspect which it (the yellow band) presents five miles off at White Ness.

An inspection of the sections at the lower portion of the cliff at Pegwell Bay, between *c* and *b*, suggests at once the idea that if the "zone of life theory" is to be relied on for so great a distance as intervenes between Pegwell and Margate, the bed of ammonites, found as above between *p* and *q*, might possibly be represented in the soft chalk on this the southern side of the island. It might be, but it is not—and for this reason that the cliffs at Pegwell Bay give you, in my estimation, no chalk so high as that in which the bed found between *p* and *q* lies.

They very nearly reach it, but they do not quite do so. In my judgment, the highest chalk at Pegwell Bay does not come within* 20 feet of that bed, in fact, if it reaches to within 40 feet of it, I suspect it is quite as much as it does.

But now I am able to give you a most striking and interesting fact in connection with this side of the Island, for although no chalk corresponding to that in which lies what I will call the upper bed of Margate Ammonites, is to be found at Pegwell Bay, yet there is a bed of ammonites to be seen at Pegwell, which, if I am not mistaken, corresponds very closely, if not exactly, with the horizon of the lower bed, indicated by the specimen mentioned to me by Mr. Stoddart.

Before preparing this paper, I applied for assistance and information to our fellow associate, Mr. Cecil Wray, a gentleman who

* Subsequent measurements show that it comes within about ten feet of it. See "Geological Magazine," l. c.

with his brother, Mr. Leonard Wray, has made the geology of the Isle of Thanet a close personal study for many years, and he informed me that he and his brother had found several ammonites at points between *b* and *c* in the second section. And I may here say, that I had, in fact, searched in Pegwell Bay when I was there the other day, for ammonites in the cliffs between *b* and *c*, feeling quite sure that they ought to be there if, that is to say, the zone of life theory was to be depended upon over so large an area, but having only a very short time at my disposal, I missed all trace of them. It was most gratifying, therefore, to find from Mr. Wray that here again there is a very strong indication of the accuracy of the theory—that it again guided me right, and that I only missed the same success as that to which it led me before, by not having eyes quick enough to discover those evidences of its trustworthiness which the cliff actually contained, and which the gentleman who so kindly gave me these particulars has now enabled me to lay before you.*

It will be noticed that I have said that some of the upper portion of the Margate Chalk appears to be unrepresented in the Chalk Cliff at Pegwell Bay. Now if this could be announced of that portion of the Pegwell Bay Chalk which is surmounted by the Thanet Sands, the fact would have an important bearing on the question whether there has been denudation of the Chalk before the Thanet Beds were laid where we now see them. Most unfortunately the junction bed of the Chalk and Thanet Sands is not visible; but with respect to the quantity of chalk in section at Pegwell Bay, I feel the greatest confidence that I am right in my statement, and if any one will take the three-inch band of flint as a datum line, I feel certain that an accurate measurement of the two cliffs will lead to the result that I have given, and that one cliff will be found to contain a depth of from 20 to 40 feet of chalk less than the other.†

I understand that this question of denudation is one of the disputed points on which geologists are not quite agreed. Mr. Whitaker, in his delightfully comprehensive and exhaustive work on "The Chalk Basin of London," opposes altogether the notion

* Mr. L. Wray has since found four more *in situ* between *b* and *c*. See "Geological Magazine," l. c.

† This is so by subsequent measurement. I make out 51 feet of chalk in section between *m* and *q*, which is not represented between *b* and *c*, and has been carried off the cliff.

of any denudation at all of the Chalk where the Thanet Beds lie upon them, and he suggests, as I understand his work, that whatever signs there are of such action are to be attributed to the decomposition of the Chalk by chemical products, and not to any atmospheric or other denuding causes. He admits, as I understand, that an interval between the Chalk and the Thanet Beds must be recognised, but he disputes the fact that there is any appearance of denudation going on during that interval. This is a point to which I can only thus call attention in passing, and is one in which I cannot pretend to be in a position to offer even a suggestion, much less give an opinion.*

Before proceeding to refer you to the notices given in the Books of Ammonite life in the Chalk, I may mention that Mr. Whitaker, in his work just referred to, mentions that there is a band running for a considerable distance from Cap Point along the top of the cliff, between Deal and Dover, and which he suggests is identical with the "three-inch band" in the Isle of Thanet, for he had not failed to recognize the striking features which this line of flints exhibits in the Isle of Thanet, in the course of his field work there, and makes special mention of the band. This same band is again mentioned in the same work, p. 29, as appearing inland in Kent, on the London, Chatham, and Dover Railway,† at Shepherd's Well station, ten miles from the coast, and as being there accompanied by the flintless chalk of Margate, and I am not without hope of being able to identify it still further to the northwestward, and if it does extend so far, the great area it covers will, I anticipate, prove to be a most important phenomenon amongst the various illustrations of flint action existing in England.

Of the Beds of Ammonites mentioned in the Books as corresponding with the specimens found at Margate, the lowest appear to be those at Brighton, Lewes, and Beachy Head, and of these,

* The question, as stated in the text, really does not arise between points *b* and *c*, because the Thanet Sands only lie between *a* and *b*, and there is a fault at *b*, and the junction bed lies close down by the shore-line; so that there really is no Chalk cliff under the sands to decipher. Mr. L. Wray thinks there are signs of a junction bed to the right of the fault that is between *b* and *c*, but I think this is doubtful. Mr. C. Wray tells me there are Thanet Sands between *g* and *h*; if so, that will be the locality in which to examine into the point, as there would be a junction bed there.

† I have since visited this locality, but I cannot feel confident that the beds are identical; if they were, I should have expected to find traces of the Margate Zone of Ammonites, which is not 14 feet above the three-inch band, and as the cutting is 40 feet high, and the flints rise from the ground, there is plenty of room for the zone, but I found no signs of it.

that at Brighton is close to the Black Rock and the Elephant Bed, and is situate in Lower Chalk—the ammonites there being very large. I have not seen the bed itself, but understand that it is visible only at low water, and that the specimens lie in a true horizon on the beach. One of them has been extracted and placed in the new Museum at Brighton, and it is named *Ammonites Lewesiensis*. This specimen is a little over 3 feet in diameter, and was shewn me by that highly accomplished geologist, Mr. Davidson, who also gave me particulars of an ammonite which he saw at Nice, in the garden of M. Geny, which was six feet eight inches in diameter, and which was, as Mr. Davidson understood, a specimen from the Neocomian strata in that neighbourhood.

Passing by the beds at Beachy Head and Lewes, of which I find few records, the next bed to which we arrive is the bed at Dover; this bed is mentioned by Professor Phillips in his Paper, in 1821, on the Chalk between Walmer and Dover, but I am unable to give any particulars of it, as that gentleman gives no details respecting its exact locality. On the subject of this Dover bed Mr. Sowerby, in his Mineral Conchology, mentions an ammonite on the beach there 3 feet across, but does not know the species, and does not indicate precisely the position. Mantell, on the Fossils of the South Downs, also refers to a specimen from Dover, but he also gives no specific particulars as to the exact locality. Nearly all these specimens, if named at all, are called *Ammonites Lewesiensis*.

With respect to the Lewes Bed I can only say that I find it is represented by specimens mentioned in Dr. Mantell's "Fossils of the South Downs," namely, *Ammonites peramplus*, and *A. Lewesiensis*, both large fossils, but the particulars of the bed, as a bed, are not given.

Mantell also mentions *A. peramplus* as a fossil to be found at Beachy Head, and, as I understand him, in Upper Chalk there. He considers it distinct from *A. Lewesiensis*, but Mr. Sowerby considers the latter as being a compressed form of *A. peramplus*. I can, however, find no particulars of the position of the bed at Beachy Head. I have addressed the Rev. E. S. Dewick, who is interesting himself in the Museum at Eastbourne, on the subject, and he kindly informed me that he has no record of any ammonites being found at Eastbourne, except that furnished by Mr. Mantell's works. I may add that it appears from Mr. Whitaker's "Geology of the London Basin," p. 19, that large ammonites are found at Selborne, in Hampshire, but the dimensions are only from 14 to 16

inches. Again, *A. peramplus* is mentioned by Mr. Caleb Evans as being found near Caterham, in the upper portion of the Lower Chalk, and ammonites are also referred to by Mantell as appearing at Croydon and the neighbourhood.

With respect to the Margate Bed, Dr. Buckland, in his "Bridgewater Treatise," states that Sir T. Harvey and Mr. Keith Milne had found ammonites at Margate exceeding 4 feet in diameter, but the particulars of the information thus given to Dr. Buckland are to be found in print I have been unable to discover them, and can find no particulars of the bed as a bed in any book to which I have referred.

Mr. Sharpe, in his "Mollusca," gives Kent, Sussex, Surrey, Hertfordshire, Wiltshire, and the Isle of Wight as the habitat of this large species, called *A. peramplus*, but, he says, it is only large in the Lower Chalk, and dwindles in the Upper Chalk,* and he says it is only very old specimens that exceed two feet in diameter.

The other large ones which he gives are *A. leptophyllus* and *A. Lewesiensis* which, however, he considers †identical, and as of an average diameter of two-and-a-half feet. The habitat he gives as Upper Chalk of Brighton, Ramsgate, and Greenhithe.

Mr. Dowker, in the interesting paper "On the Chalk of the Isle of Thanet," which he read here in 1870, mentions having large specimens of *A. leptophyllus* and *A. Lewesiensis* from Margate, in his possession; one nearly five feet six inches in diameter, and also flint casts of two other species, but he does not mention the respective positions in the cliff of any of these specimens.

The works to which I have referred on the subject will be found in the tabular statement given below, which may prove useful to other students.

CONCLUSION.

Now if the particulars which I have thus given the Association have any value at all, I anticipate that that value will be in the following deductions. And I shall proceed to make deductions

* I have lately found *A. peramplus* at Margate, over two feet in diameter.

† I would suggest whether *A. peramplus* is not identical with the two here named, and that it represents the cast of the external form of the shell, generally ribbed with fluted radiating undulations, as the animal appeared in life—that then *A. leptophyllus* represents this outer shell slightly worn off, and down to a level, where the sutures are richly foliated at the lines of junction with the outer shell; that, thirdly, *A. Lewesiensis* represents the shell worn off and down to a lower level still, and nearer to the central plane, and to a level in which the foliations are coarser and less refined. I have a flint cast which, as I read it, exhibits all three markings. The object of foliating the suture seems to have been to give great strength to a very thin shell required to support a prodigious weight of water.

rom my facts upon this principle, that even a bad deduction is
etter than none at all, because it not only suggests argument, but,
urther, if one gives a deduction which is proved to be wrong, why
ne has the satisfaction of knowing that somebody else is probably
roved to be right. In the first place, I think I have shewn
eason for earnestly commending to every field student, who is
ngaged in examining the Chalk, to hold fast by this theory of
Zones of life," or "Zones of death," whichever may be the most
ppropriate name. They are, as I understand the term, zones
f successive existence. Moments of maximum and minimum—
anges, in fact, of special fossil life within the limits of the
Cretaceous System. The guide may fail at times, but I have shown,
think most convincingly, that in one, if not two, distinct instances
t is a guide which has proved itself to be a most faithful and trust-
vorthy friend.* In fact, I will go so far as to say that I could
ave found many of the specimens, which I have indicated,
ctually blindfold, with this theory to lead me on. Now, if
he theory can be even partially sustained, the importance of it in
lealing with the Chalk is so obvious that it would be as pre-
umptuous as it is needless for me to do more than just glance at
ne of the consequences that would probably ensue from its being
stablished. In comparing the Chalk of Norwich, say with the
Chalk of Margate, by the fossil productions of each situation, it is
mpossible not to feel a certain sense of hesitation in accepting the
vidence on which the two are compared, when it is founded
nerely on the similarity of two cabinets full of fossils taken from
ach locality. The feeling will occur to the mind that although it
s true that fossils *a*, *b*, *c*, *d*, *e*, *f*, and *g* may be found in each place in
reat abundance, yet that if some day it should turn out that the
rder in which these fossils prevailed most abundantly in each sea
as not identical, in other words, that the succession of the zones
as different, away would go the evidence of relation at a blow.

But, on the other hand, if it could be shown not only that there
ere "zones" of identical life in each cliff, but that the moments of
aximum for each zone succeeded each other in the same order in
ach sea, it would become in the highest degree probable that
he two oceans were connected together, and were, in fact, co-
xistent in point of period.

* It most undoubtedly is so; see results of further search, "Geol. Mag.," l. c.

Now, to any one who once becomes satisfied of the value of the "Zone theory," in dealing with the Chalk, it will be at once plain that it is of the utmost importance that he should preserve most carefully accurate details of the position in every Chalk cliff or bed of every fossil extracted from it. While further, he will, I think, be satisfied that, at any rate, until he is a very advanced student he will find it more profitable to endeavour to hunt the cliff's side over, as I did, in true horizons, rather than in an indiscriminate search all over its surface for every variety of fossil which the spot can produce.

Let me venture to press this matter on my student fellow-associates by an illustration.

Suppose anyone were to inform you gravely that Milton, Queen Elizabeth, Chaucer, Pope and Shakespeare, lived sometime between the age of William the Conqueror and William IV.—how much wiser would you be for the information? But suppose that he who gives you this information had it all the time in his power to find out not only the exact order in which these five lives successively followed each other, but as to two of them might have recognized the fact that they lived in the same zone of human life. If he fails to do so, surely you would have good cause to regret not only that he had omitted to bring away the evidence of their relative positions, but still more that he had actually destroyed the very evidence, in fact, perhaps the only evidence which would have enabled you to make the comparison for yourself. And yet this is what everybody does who removes from a Chalk cliff a fossil without preserving as exact a record of its position as he can obtain. It is on this point that the paper of Mr. Caleb Evans on the "Caterham Chalk," appears to me to be so highly philosophical, and if I may take the great liberty of saying it, so worthy of all praise, because he brings out so admirably the value in the Chalk formation of a *datum line*—a line, that is to say, to which you are to refer the position of every fossil you find. Every observer, of course, must select his own, and for each section. It matters not what it is, so long as it is as permanent a one as the nature of the circumstances will admit—such as every one can find, and one which the observer himself duly records. If he will only work by such a line, then the more fossils he takes home to his cabinet the better; but if he neglects such a preliminary, then, by every fossil that he takes out of the cliff, he deprives that cliff

side of an evidence which might be used in determining the relative positions of those zones of life which, whether they are fully represented by its fossils, or whether they are not, must, as it stands to reason, have followed each other, and attended each other in variable succession through the Chalk Sea. Just think of the multitude of years by which two fossils may be separated in point of time, though the amount of chalk between them may be only a foot or two, and only see the value to me of a "datum line" in the case before us. Until I had selected one, I actually could not find the fossils at all; and when I did select such a line, I found them immediately. Only suppose, too, that sixteen observers had taken out these sixteen ammonites one after the other at different times in a scramble for specimens; think how valueless would be the testimony of these fossils compared to what it is, now that they are all found by one pair of eyes, and allowed to remain in position for their exact attitude to be discussed and considered. I can prove to you that I am not speaking without good cause, for I can show you that the science of systematic geology, if I may so describe it, is actually suffering severely by the want of a due regard to the feature to which I am calling your attention, and that so far as the Chalk is concerned, the fascinating and more accessible paths of palæontological research have drawn men away from the unattractive and, apparently, less fruitful track of biological knowledge, and that in a strata where Mr. Darwin might well have expected that science would have provided him with some of its most valuable illustrations there are few, if any, records at his disposal. Notwithstanding the multitude of beautiful collections of Chalk fossils which surround us on all sides; notwithstanding the ardent work done by so many students for so many years in collecting Chalk fossils, this is what Mr. Whitaker says, in the year 1872, in his work already quoted, "After having taken much trouble in compiling a list of the fossils from the Chalk surrounding the London Tertiary Basin, I have been led to the conclusion that the existing data are not trustworthy enough to furnish a really good list; in *many cases the localities given cannot be depended on, and often the divisions of the Chalk from which the fossils have been got are equally doubtful.*" And, accordingly, he is only able to refer to the four papers on the subject by Mr. Etheridge, Mr. Saunders, Mr. Caleb Evans, and Mr. Dowker, which he quotes, and gives no table of fossils from

the Chalk except one from the "Chalk Rock," which being a zone lithologically speaking, of course there could be no mistake about.

I wish heartily I could inoculate my brother students with ever so little of my own indifference, so far as the chalk is concerned, to the "*mere*" collecting bag, and to a gathering together of many specimens. Believe me, and everyone who has tried it knows from pleasant experience, that natural science offers on all hands doors of delightful observation which will open to everybody, however unskilled and unapt he may be, if he will only consent to take up, however humbly, one single thread, and resisting the temptation to look at any other will follow that one thread as far as it will lead him, and that one thread only. It may seem presumptuous in me to say so, but I had rather place before you the information I have given this evening, trifling and insignificant as it really is, than I would have brought you in a cabinet full of indiscriminately collected fossils. I grant that the information I bring bears no comparison with the time apparently spent upon it; but, then, it was but idle work done by idle eyes in idle hours; it was a holiday task, and if an energetic, persistent student had had the work to do he would have found no difficulty in executing it all in a twentieth part of the time which it has occupied me. But how, I ask, would he have done it? how alone could he have done it? Why, by persistently refusing to be led away down those tempting bye-paths which nature is for ever exhibiting to the eye to induce you to leave the one thread you are determined to pursue.

Finally, allow me to add one last deduction from the circumstances under which this paper comes before you. There is, in my humble judgment, a very large number of persons who are at present frightened away from all science, and particularly from Geology, by a belief that there is some mysterious form of introduction, a long and severe apprenticeship in book learning, and a heavy, long-syllabled nomenclature that must be waded through before they can be of any practical use to the science which they are looking at with wistful eyes. Persons whose services would be of the utmost value to science generally, and more especially to a science like Geology, if they could but be induced to realise that there is a vast field of work—original untrodden work, too—open to them, without it being in any way necessary for them to do more than simply use persistently the eyes which God has given them; and to these I would say this, there

two modes in which every student can learn—one in the pages of printed books, the other in the pages of Nature's book—and if a man will only sit at Nature's feet, even without a particle of book learning, she will assuredly smile on him at last, and teach him with her own exquisite voice lessons startling in their reality and delightful in their freshness. It was in this, and in no other way, that that self-taught, self-developed, high-souled Scotchman, Hugh Miller, learnt all his important lessons. True, the first crude thoughts, the first independent views, may be erroneous ones, but gradually the film falls from the eyes; the cliff side, which was at first misapprehended, and regarded as a blank mass of unmeaning solidity, gathers, as it is gazed at, shape and form—it becomes instinct with life—it breathes, it lives before you. You approach it—you walk beside it no longer as a mere rock—but as the bed, the ever changing, ever rising bed of a mighty ocean—and whether you know the nomenclature of its contents, or whether you do not, what matter! You can read lessons, you can collect history from its mighty depths, from the moment that you first realise and appreciate what it actually represents—lessons which no book in the world that ever was written can unfold to you—lessons which Nature and Nature's God alone can teach you!

It is to this class of observers that I address myself; and as one of themselves I urge them not to be daunted by any apparent severity in the course of study which they think is required to make them capable of being coadjutors to scientific men, for none such is absolutely required; and I urge upon them to supplement Nature by books, not books by Nature—to go to Nature first, and there collect their facts, and then to pass from her to Science. *

It is true we may not know the importance, the relative value, of the facts we collect. Still we can but gather them up—we can but lay them before those highly gifted and more fully instructed minds, which so worthily occupy the higher positions at the head of Geological Science, and though for ourselves we may never aspire to arrange the materials or to build up the walls of the fabric itself, yet there are master-minds amongst us who are engaged in the task, and who are able to execute it; and we can but bring our small contributions to them, as I have done now, as materials for the intricate structure which they are raising, leaving it to them to say whether those con-

* Students who have attended the delightful field excursions of the Association, will appreciate, I am sure, the accuracy of this proposition.

tributions can be made available in the great work on which they are engaged.

Readers interested in the matter of this essay, are requested to accept it as a first and partial approximation to a solution of the subject investigated. A second approximation, the result of more systematic work, will be found in the "Geol. Mag.," Dec. 2, Vol. i., January, 1874, and I hope that others will follow. I have to express my obligations to Henry Woodward, Esq., F.R.S., Editor of the "Geological Magazine.," and to the proprietors of that journal for kindly allowing me to use the illustrations which accompany this paper. Any student desirous of visiting the Isle of Thanet Section is advised to go at neap tides, as the springs bring the high tide on at midday, and then access to the shore is impossible for several hours before and after that hour.

WORKS OF REFERENCE.

Year.	Author.	Reference or Page.
1821	Phillips—"Chalk Cliffs near Dover"	Geol. Tran. v. p. 30.
1822	Mantell—"Fossils of the South Downs"	pp. 198, 200.
1823	Sowerby—"Mineral Conchology"	Vol. iv., p. 79.
1833	Mantell—"Geology of South East of England"	pp. 79, 125.
1835	Fitton—"Strata below the Chalk"	Geol. Tran. iv.
1836	Buckland—"Bridgewater Treatise"	Vol. i., 334.
1857	Mr. Sharpe's "Mollusca"	Palæon. Soc.
1865	Mr. Whitaker—"The Chalk of Isle of Thanet"	Geo. Qrt. Jou. xxi. p. 395
1870	Mr. Caleb Evans—"Chalk between Croydon and Oxted"	Geol. Assoc.
1870	Mr. Dowker—"The Chalk of Thanet," &c.	Geol. Mag. vii., p. 446.
1872	Mr. Whitaker—"Geology of the London Basin"	Geol. Survey, Vol. vi.

EXCURSION TO BRIGHTON.

JUNE 11TH, 1873.

Directors.—The PRESIDENT, HENRY WOODWARD, Esq., F.R.S., F.G.S., &c., and Professor T. RUPERT JONES, F.R.S., F.G.S.

On arrival at Brighton the party crossed the South Downs to the "Devil's Dyke," at the summit of the escarpment overlooking the Weald; and here, illustrating his remarks by maps showing the changes in the physical geography of this part of the globe which have occurred during various geological epochs, Professor T. Rupert Jones, F.R.S., explained the theories which had been advanced to account for the denudation of the Weald.

The Professor first referred to the hypothesis of the upheaval of the elliptical area of the Weald causing axial and transverse fissures in the Chalk. This upheaval gave rise to several rivers running north, and corresponding ones running south, which now drain the Wealden Area. The advocates of the sub-aërial denudation hypothesis maintain that the action of rain and rivers sufficed to complete the work of denudation; but it is contended, on the other hand, that it must have been consummated by submarine action. This latter opinion was strongly advocated by Mr. S. J. Mackie, who had very ingeniously shown the manner in which the sea would act, and form a long bay corresponding to the present Wealden Area before the formation of the Straits of Dover. The lecturer concluded by some general observations on the changes which had occurred in the physiography of this part of the globe.

Mr. Woodward concurred in the opinion that Mr. Mackie's theory had scarcely received that careful consideration which it seemed to him it deserved, and adduced various phenomena that would be difficult to account for on the hypothesis of sub-aerial denudation alone.

Returning to Brighton by way of the Western Valley and past Furze Hill, the area of the Tertiary Deposits, the party traversed the whole length of the Coast Section, and alighted at Kemp Town to observe the "Elephant Bed," which was especially well seen in consequence of a recent fall of a portion of the Cliff. This remarkable bed, and the underlying "raised beach" resting on the undisturbed Chalk, were very attentively examined.

After luncheon the new Museum was visited. The visitors were

received by the Chairman of the Museum Committee, Mr. Thomas Davidson, F.R.S., and the Curator, Mr. G. Scott; and the Davidson collection of foreign fossils and volcanic products, the Willett collection of Cretaceous fossils, and the contents of the Museum generally were subsequently inspected. Mr. Woodward lucidly explained the general arrangement of the Museum, which he regarded with especial interest, as well as the great share Mr. Davidson had taken in bringing together a collection which was worthy of the important town of Brighton. Professor Rupert Jones then discoursed on the Elephant Bed, attributing this great aggregation of Chalk *debris* against undisturbed Chalk to a "banking up," which would be produced by a reflex action of the tides consequent upon the obstruction of the isthmus which existed where are now the Straits of Dover. After thanks had been duly tendered and responded to by Mr. Davidson, the Members proceeded to the Aquarium, to visit which they had been courteously invited.

The remainder of the time at the disposal of the party was thus instructively and agreeably spent, and the return to London by the evening train concluded the day's proceedings.

EXCURSION TO HATFIELD.

JUNE 28TH, 1873.

Director.—J. LOGAN LOBLEY, Esq., F.G.S.

Though little visited as a locality of geological interest, the neighbourhood of Hatfield presents sections both of the older and of the newer Tertiaries of considerable importance. Situated on the northern edge of the London Tertiary Basin, Hatfield is an advantageous point of departure for a geologist who wishes to trace the junction line of the Secondaries and Tertiaries. To enable the Members of the Association to traverse this line, and to inspect the principal section showing the junction of the beds, the Marquis Salisbury courteously threw open Hatfield Park.

This wide-spreading domain, with its gentle undulations, bearing oaks and elms and limes, afforded to the visitors a typical example of London Clay scenery; while the fine old Tudor house, with memories of Queen Elizabeth, carried their thoughts back to the a

when Bacon was laying the foundation for the science of to-day, and chivalry and poetry were giving to Britain a glory for all time.

On reaching the extreme eastern limits of Hatfield Park the party entered an extensive excavation, in which are seen all the beds occurring in this locality between the London Clay and the Chalk which forms the bottom of the excavation, with the high level Post-Pliocene gravel capping the whole.

Mr. Whitaker, in his important work "The Geology of the London Basin," p. 226, gives the following details of this section :—

		FEET.
	Gravel composed of various sized pebbles of flints, white and pink quartz, quartz rock, and some other rocks, and subangular flints, in coarse whitish sand, in parts as much as	6
London Clay.	Stiff brown clay, more sandy towards the base	20
London Clay. Basement Bed.	Brown loam with green grains	about 7
	Thin bed of brown clay	
	Olive green and dull brown sand	
	Dull brown sand with green grains and perished shells	
	Brown loam with small nodules of stone and perished shells	
	Thin bed of flint pebbles, mostly small	
Reading Beds.	White and light-coloured sand, with layers of grey laminated clay; at parts some very small pieces of ironstone, and here and there a flint pebble; for the most part regularly bedded, but a little false bedding in the lower part	about 23
	Bottom Bed—Fint pebbles and subangular flints; very dark green (almost black) outside, in sand; the upper part ironshot, the middle grey and greenish yellow, the base iron shot; greatest thickness	about 2
	Chalk with flints. Junction even and with a dip about S.E.	

It will be noticed that the Thanet Sands are not present here, and that the beds immediately below the London Clay Basement Bed have the character of those near Reading rather than of those in the neighbourhood of Woolwich, while the mottled Plastic Clay is entirely wanting. The sands overlying the Chalk might be mistaken for the Thanet Sands, but the thinning out of those deposits considerably to the south of this locality, and the evidence of other sections in the district, leave no room for doubt as to the age of these beds. A multitude of sand-martins find a home in the sands, which are quite honeycombed by these industrious excavators. The section—its teachings, its similarities to, and differences from other sections showing Tertiary Beds above the Chalk—having been explained, the party left the picturesque spot, and ascended to the higher level, where a brick-pit exposes a continuation of the section, and shows the High Level Gravels capping the London Clay.

The Members now proceeded by a north-western route for a dis-

tance of about three miles to a cutting on the Great Northern Railway, where a section nearly half a mile in length exposes the Middle Glacial sands and gravels, with a thin overlying sheet of Boulder Clay forming the subsoil of the land. The railway to Hatfield was then traversed, and the sections of the Glacial Beds along this part of the line were examined by the Members. On arriving at Hatfield the party re-united, and subsequently took train for London.

ORDINARY MEETING, JULY 4TH, 1873.

HENRY WOODWARD, Esq., F.R.S., F.G.S., President, in the Chair.

The following Donations were announced :—

"Report on the Progress of the Geological Survey of New Zealand, during 1868 and 1869;" from Captain F. W. Hutton, F.G.S.

"Reports of Geological Explorations in New Zealand, 1870—1872," published by the Geological Survey of New Zealand; from Captain F. W. Hutton, F.G.S.

"Geological Survey of Indiana, with Maps;" from E. T. Cox, Esq., State Geologist.

"Memoir of Sir Benjamin Thomson," by Count Rumford; from the Smithsonian Institution.

"The Complete Works of Count Rumford;" from the Smithsonian Institution.

"Fortieth Annual Report of the Royal Cornwall Polytechnic Society;" from that Society.

"Report and Proceedings of the Miners' Association of Cornwall and Devon, 1872-3;" from that Association.

"Proceedings of the Bristol Naturalists' Society," Vols. iii. to vii.

"Address to the British Association at Brighton, 1872," by W. B. Carpenter, M.D., LL.D., F.R.S., &c.; from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Address to the Geological Section of the British Association, 1872," by R. A. C. Godwin-Austen, B.A., F.R.S., F.G.S., &c.; from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Abstracts of Proceedings of the Geological Society of London;" from that Society.

"Sketch of a Geological Map of Victoria;" from Henry Woodward, Esq., F.R.S., F.G.S., F.Z.S., Pres. G. A.

"Further Remarks on the Relationship of the Xiphosura to the Eurypterida and to the Trilobita and Arachnida," by Henry Woodward, F.R.S., F.G.S, F.Z.S., Pres. G. A.; from the Author.

"On the Denudations of Norfolk," by the Rev. O. Fisher, M.A., F.G.S.; from the Author.

"The Coprolite Pits of Cambridgeshire," by the Rev. O. Fisher, M.A., F.G.S.; from the Author.

"Descriptive Guide to the Fossil Collection in the Museum of the Leeds Philosophical and Literary Society;" from W. Whitaker, Esq., B.A., F.G.S.

"On the Geological Position and Features of the Coal and Ironstone Bearing Strata of the West of Scotland," by James Geikie, F.R.S.E., Edinburgh; from W. Whitaker, Esq., B.A., F.G.S.

"Sketch of the Geology of the Neighbourhood of Banbury," by Thomas Beesley, F.C.S.; from the Author.

The following were elected Members of the Association:—

Arthur M. Butt, Esq.; Rev. Robert Dixon, M.A., LL.B. F.G.S.; Frederick Hovenden, Esq., F.R.M.S.; Thomas Jesson Esq., B.A., F.Z.S.; Edward Powell, Esq.; and William Priestland, Esq.

The following Papers were read:—

1. Sketch of the Geology of Northamptonshire.

By Samuel Sharp, Esq., F.S.A., F.G.S.

The county of Northampton possesses many points of great geological interest. It is situated about midway upon the great belt of Oolitic and Liasic formations, which traverses England from the coast of Dorsetshire on the south, to the northern shores of Yorkshire on the north-east. Taking a general section of the county, we find that the Lias forms the great basal formation, and has an aggregate thickness of about 850 feet, consisting of from 150 to 200 feet of the Upper Lias, about 30 feet of the Middle Lias, or Marlstone, and something like 650 feet of the Lower Lias. The clay of the Upper Lias is largely worked for brick-making; but the bricks of Northamptonshire are not remarkable either for quality of material or for colour, either when new or weathered.

This clay abounds with palæontological remains; such as those of large *Ichthyosauri* and *Teleosauri*, *Ammonites* and *Belmnites*, *Gryphæa*, *Ostrea*, and other bivalves, &c. It has also yielded a unique crustacean, a clawless lobster (like a large prawn), *Peneus Sharpii*, Woodward.

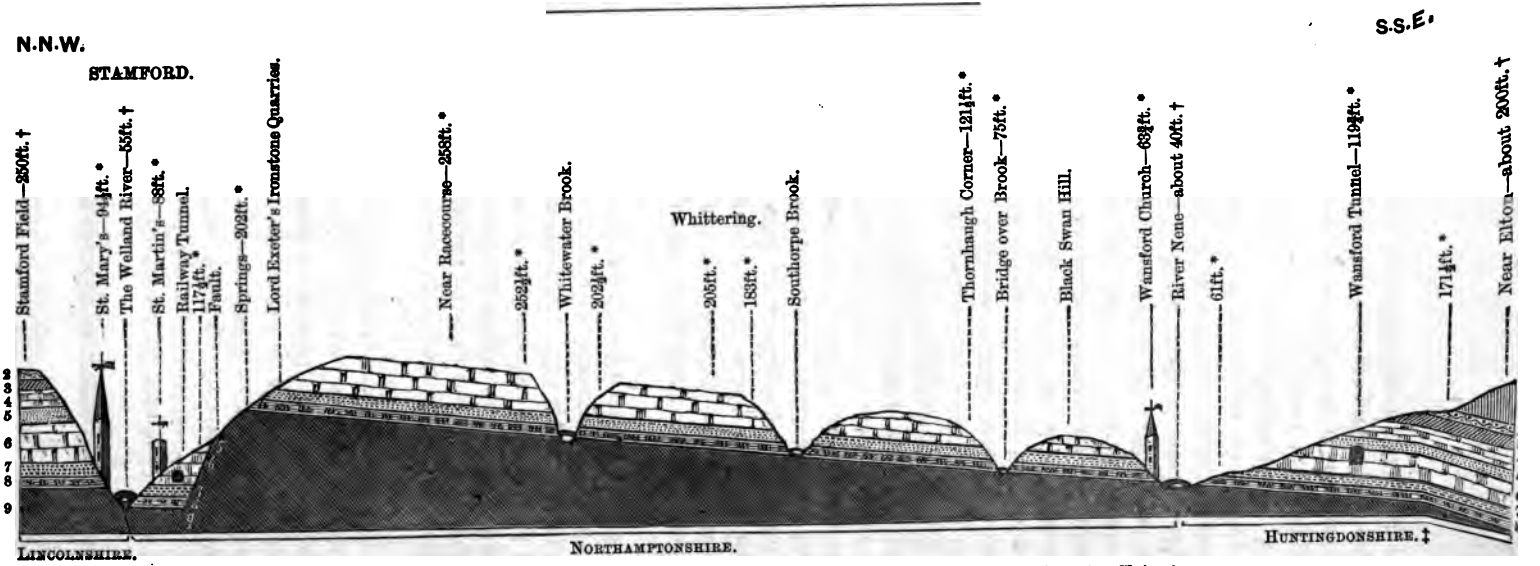
The Middle Lias, or Marlstone, is an abundant water-bearing formation, and from this, by a well 168 feet deep, the Water Company of Northampton furnishes to the town a copious supply of pure and not hard water. It is characterized by the presence of *Rhynchonella tetraëdra*, Sow., very large *Pecten æquivalvis*, Sow., &c.

Above the Lias, repose the peculiar and interesting Inferior Oolite beds of the "Northampton Sand" (so called by the Government Survey), having an aggregate thickness of about 80 feet. These beds have been classified into two divisions—the lower division, of about 60 feet in thickness, being that which yields an abundance of iron ore, for which Northamptonshire has become so famous. This ore has now (1873) been worked for upwards of twenty years, and during that time a quantity exceeding a million and a half tons of pig-iron has been produced. At the present time, about 20,000 tons per week of the ore are being excavated, yielding on an average nearly 40 per cent. of pig-iron. One-fourth of this ore is smelted in the district, but the greater portion is sent off for admixture with other ores to Merthyr Tydvill, in South Wales, to the Tees, and to Staffordshire. It is remarkable that in the Roman times—probably in the third and fourth centuries—Northamptonshire was a great iron-producing district; but its resources in this direction remained dormant until about the year 1850, when the discovery of the great value of these iron-bearing beds was again made. The beds of the lower division, depending upon local favourable conditions, yield easily-worked, durable, and richly-coloured building stone. They are highly fossiliferous, and have yielded many species not known in other districts: among these are a star fish—*Stellaster Sharpii*, Wright; and the bivalves —*Lima Sharpiana*, Etheridge; *L. Dustonensis*, Eth.; *L. deltoidea*, Eth.; *L. Rodburgensis*, Lycett, M.S.; and a large *Lima* allied to *L. Grandis*, Römer; *Trigonia Sharpiana*, Lycett; and others not yet described; a tooth and pelvic bone of *Megalosaurus*, a dorsal scute of an undescribed species of *Teleosaurus*, &c.

The upper division of the "Northampton Sand" consists of a nearly white siliceous sand, frequently intercalated with clay (worked

Fig 1.—**Section from Lincolnshire at Stamford through Northamptonshire into Huntingdonshire, nearly on the line of the Great North Road.**

Horizontal Scale—One inch to a mile. *Vertical Scale—About One-tenth of an inch to 30 feet.* *Heights—above mean sea level at Liverpool, taken from Ordnance Survey Bench-marks.*



1.—Oxford Clay.
2.—Cornbrash.
3.—Clay.
4.—Limestone. } Great Oolite.
5.—Upper Estuarine.

6.—Lincolnshire Limestone and Collyweston Slate.
7.—Lower Estuarine } Northampton Sand. } Inferior Oolite.
8.—Ferruginous Beds
9.—Upper Lias Clay.

* Heights above sea level—taken from Ordnance Survey List of Bench-marks.
† Heights above sea level—estimated from neighbouring Bench-marks.
‡ The Huntingdonshire portion of the Section is contracted about three-quarters of a mile.
N.B.—The Datum Line represents the mean sea level at Liverpool.

for terra cotta in the neighbourhood of Stamford); and in places exhibits, *in situ*, a plant bed, with horizontal layers of super-growth, overlying a bed (running to 18 inches) of vertical root perforations. Some geologists, however, have considered that the latter are not root perforations, but are the traces of equisetal plants. Sometimes this white sand is found sufficiently indurated to constitute a good building stone. Many important buildings, including the Northamptonshire General Infirmary, were built during the last century of this stone.

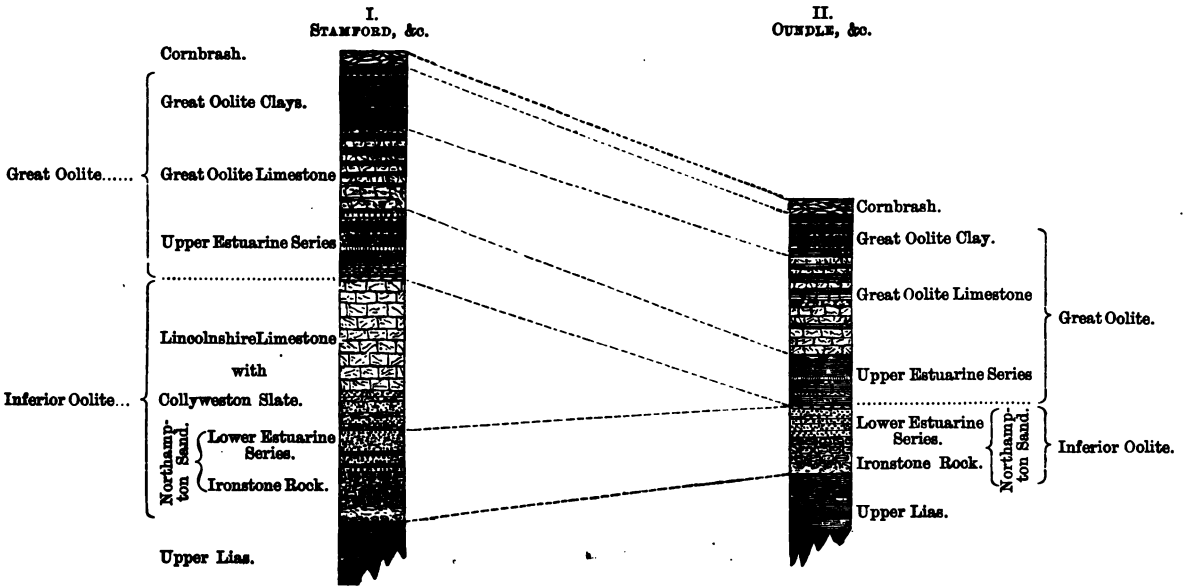
The upper division and the upper part of the lower division of the Northampton Sand, as indicated by the presence of plant remains, much drifted wood, certain bivalve and univalve fossils, and by the frequent occurrence of ripple-marked surfaces, had partly an estuarine and partly a littoral origin. The upper division has been termed by the most recent geologists, in contradistinction to higher beds in the district having similar characteristics, the "Lower Estuarine" series.

The Lower Estuarine series, in the Northern and Eastern parts of the County, is surmounted by a very important formation, made up of several and very various beds, chiefly of oolitic limestone, and which, traversing Rutland and passing into Lincolnshire, where it has attained its greatest development (a thickness of about 200 feet), has hence been called the "Lincolnshire Limestone." The fossiliferous contents of these beds demonstrate that they are also Inferior Oolite; and other reasons there are for concluding that they are the uppermost group of the Inferior Oolite series in this district.

At the base of the "Lincolnshire Limestone," occurs, at Collyweston and Easton, a thin bed of a calcareo-arenaceous character, which, upon exposure to frost, readily splits up into slates, not in the planes of cleavage as in the case of Welsh or Westmoreland slates, but in the planes of its finely laminated stratification. This slate is extensively used in the district, having, in ancient times, formed the prevalent roofing material of the locality, and has been employed by Sir G. Gilbert Scott, the celebrated architect, for the roof of the new chapel of St. John's College, Cambridge, as also for that of the rebuilt nave and aisles of St. Sepulchre's Church, Northampton, and other important erections. The production of these slates forms the staple trade of the two important villages named above, and furnishes employment to a considerable industrial population. These slate beds are probably a local variation only. Among the more remarkable fossils found in them are—

Fig. 2.—**Sections Illustrating the Relations of the Lincolnshire Limestone to the Northamptonshire Oolite.**

[*Reprinted from the* "QUARTERLY JOURNAL OF THE GEOLOGICAL SOCIETY," *by permission of the Council.*]



a beautiful and previously unknown winged univalve, termed *Pterocera Bentleyi*, after a gentleman well known in the district; a crustacean of the genus *Pseudophyllia* (a small lobster); and a unique star fish, found by the writer—*Astropecten Cotteswoldiæ*, var. *Stamfordensis*, Wright.

Of the limestones above this so-called Collyweston Slate, the lower beds are, for the most part, marly and soft, and occasionally supply a pure cream-white stone, well adapted and much used for interior domestic work, and for carved work in churches. Higher beds yield good rough durable building stone, and are traversed by a very shelly and partially crystalline bed, the stone of which, taking a good polish, has been termed the "Stamford Marble," and is very ornamental for chimney-pieces. The whole of these beds are quarried extensively for lime-burning, the lime produced being of excellent quality.

Passing upwards from these marly beds of limestone, our attention is drawn to one of the most important building stones in the kingdom—the widely known "Ketton Freestone"; the equivalent stone in Northamptonshire being the "Weldon Stone," quarried at the place of that name. Both Ketton itself and Casterton, where a very fine example of the same stone is quarried, are only just without the confines of the county, in Rutland, which abuts on the mid portion of the northern limit of the Northern Division of Northamptonshire. This stone is of that peculiar grain from which the term "oolite" (or roe-stone, or egg stone) is derived. It is composed entirely of small egg-shaped grains, embedded in a calcareous matrix. A polished section of the stone generally shows that each of these ova-shaped grains has a minute nucleus (either siliceous or consisting of a shell fragment) enclosed in concentric calcareous films. It is a stone very easily worked, is of a good cream colour, and very durable, hardening under atmospheric exposure. St. Dunstan's Church, in Fleet Street, London, several of the colleges at Cambridge, and many churches in the district, are built of it. It is not very fossiliferous, but has yielded the characteristic forms—*Terebratula fimbria*, Sow.; *Rhynchonella spinosa*, Schlott; *R. Crossii*, Walker; *Pholadomya fidicula*, Sow.; *P. Zietenii*, Ag.; *Trigonia hemisphærica*, Lycett; *Pterocera Bentleyi*, Mor. and Lyc.; *Natica Leckhamptonensis*, Lycett; *Cidaris Fowleri*, Wright; *C. Wrightii*, Desor.; numerous fine corals; *Aroides Stutterdi*, Carruth., and other plants, &c.

Classing with, but higher in the geological scale of the county

than the "Ketton Freestone," is a very shelly kind of stone called "Barnack Rag." This stone was quarried at Barnack even so far back as the time of the Romans, and has proved to be of a very durable nature, many of the churches and several of the cathedrals of the district having been built of it. Some beds of this stone seem to be composed almost entirely of shells agglutinated together by a calcareous cement. The Barnack quarries have been exhausted for nearly 400 years, and at this time the stone is not worked in any other locality.

Above these several beds of the "Lincolnshire Oolite" lies unconformably a series of argillaceous or clay beds, having at their base a ferruginous band. These form, in this district, the lowest beds of the Great Oolite. The ferruginous band is rich in fossils of this geological division. The clays themselves have yielded, in more than one locality, remains of the gigantic crocodilian saurian the *Cetiosaurus*, also two varieties of a bivalve peculiar to this district—*Neæra Ibbotsoni*, Morris. The presence of the brackish bivalve *Cyrena*, of drifted wood, of a plant bed, and of similar characteristics to those of the "Upper Division" of the "Northampton Sand," indicate that these clays are also of an estuarine origin, and they have therefore been termed the "Upper Estuarine" series. They are worked for brick-making.

Above these clays, is a series of limestone beds, some zones of which are very fossiliferous, and yield a fine stone for chimney-pieces, hearths, &c. They burn into a good lime. A shelly and sub-crystalline bed at Alwalton, near Peterborough, takes a good polish, and has been called "Alwalton Marble." The detached slender columns of the beautiful Early English west front of Peterborough Cathedral were composed of this marble; but, they having become decomposed from atmospheric action, another material has been substituted. In some localities, these beds abound with the remains of a small lobster, a variety of *Eryma elegans*, Oppel, and generally with the teeth, scales, and spines of several species of fish, of the genera *Hybodus*, *Lepidotus*, *Pycnodus*, and *Strophodus*. From this bed at Blisworth also have been obtained two examples of a fish not found elsewhere—*Pholidophorus Flesheri*, Agassiz. From the bed at Kingsthorpe has been obtained a fine cone of a pandanaceous plant, allied to the "Screwpines" of Norfolk Island, in the Pacific Ocean. This plant is not only of a new species, but of a new genus, and has been named by Mr. Carruthers, F.R.S., head

of the Botanical Department, British Museum, *Kaidacarpum Oolitícum*. Fossil fruit of a plant (*Carpolithes*) is not uncommon in the same bed. In the neighbourhood of Oundle also, has been found an elegant little starfish, having five attenuated and tortuous rays, which has been named *Ophiurella Griesbachii*, after the late Rev. A. W. Griesbach, an eminent geologist, who formerly lived at Wollaston, in this county.

Surmounting this limestone, occurs occasionally a variegated clay bed, characterised by an abundance of the small *Ostrea subrugulosa*, Morris & Lycett. This takes the place of the Bradford Clay of the West of England. Above this is the Forest Marble, and over a wider area the Cornbrash, both of which abound in beautifully preserved fossils: over all, is the Oxford Clay, yielding numerous ammonities, belemnites, large oysters, saurians (including the huge *Pliosaurus*), masses of wood converted into jet, &c.

The foregoing represent the range of Secondary formations in the county; but the high lands are frequently capped with a thick bed of the Boulder Clay and Glacial gravels, containing fragments from nearly the whole series of Primary and Secondary Rocks:—Liassic, Kimmeridge Clay, and Oxford Clay fossils being frequently found beautifully preserved in masses of *Septaria*. The valley gravels abound with large tusks and teeth of *Elephas antiquus*, *E. primigenius*, and an *Elephas* of an intermediate species; and teeth of *Rhinoceros tichorhinus*, bones of *Hippoptamus major*, teeth of *Equus caballus* and *E. fossilis*, the core of a horn and part of the frontal bone of *Bison priscus*, and a head of *Bos primigenius*, have also been found. The peaty fluviatile bed above the gravel contains at its base numerous remains of the aboriginal small ox *Bos longifrons*, red deer, horse, wild boar, with human skulls, &c.

As to the geological geography of the county, as has been observed, the Lias forms the foundation, so to speak, of the whole district, but is exposed in the valleys. In the North Western districts, the Lower Lias is the prevailing sub-surface formation. The ironstone occurs at its greatest thickness in the neighbourhood of Northampton, or in the mid-section of the county. It is quarried largely at Duston, Blisworth, Gayton, and Stow Nine Churches, to the west of Northampton; and at Cogenhoe, Wellingborough, Finedon, Woodford, Cranford, Glendon, and other places,

east and north-east of Northampton. It ranges in the latter section as far as Stamford, where it is now being quarried upon the estate of the Marquis of Exeter. Smelting furnaces have been erected at Heyford, Wellingborough, Finedon, Islip, near Northampton, and elsewhere. The ironstone thins out in the southern part of the county, and disappears, and the iron ore of the ferruginous beds of the Middle Lias, or Marlstone, in the neighbourhood of Banbury, commercially takes its place.

The "Lincolnshire Limestone" is the characteristic stone of the Northern Division of the county, north of the river Nene; but it thins out near Kettering and near Maidwell, about eight miles north of Northampton, and does not recur in the Southern Division. Its place, for all purposes of a limestone, is taken in the middle of the county, and in the Southern Division, by the "Limestone" of the Great Oolite, which generally caps the high lands. The Forest Marble, as a hard rock, only occurs in the neighbourhood of Peterborough, and over a very limited area. The Cornbrash crops out from under the Oxford Clay (based by the Kelloway Rock) on the southern escarpment of the Nene Valley, ranging in from Bedfordshire at a point upon the boundary of the county near Rushden, and extends, by Oundle, nearly to Peterborough. In like manner, it crops out north of the Nene, near Sudborough, extending by Lowick to the Aldwinckles, and reappearing upon many escarpments near Oundle. It also caps the high grounds north of the Addingtons and Woodford, at Islip, at Bulwick, at Upton (near Castor), occurs at a lower level at Helpstone, and is the surface rock over a large area to the north and north-west of Peterborough.

The Oxford Clay overlies, and is almost conterminous with the Cornbrash, where, as stated, the latter crops out upon the southern escarpment of the Nene Valley, and it spreads out over a considerable area of elevated land far into Bedfordshire: considerable patches of it also occur in the same elevated position to the north of the Aldwinckles, and to the north and west of Oundle; while in the neighbourhood of Peterborough it occupies only the low grounds, and spreads out over the great level of the Cambridgeshire and Lincolnshire fens.

Very high table land occurs about Naseby, from the water-shed of which rise:—The Avon, which flows westwards (forming the northern boundary of the county from Welford until it passes into Warwickshire), and by Warwick and Stratford-on-Avon, into the Severn

and the Bristol Channel; the Welland, which takes an easterly direction, and passing by Stamford to Spalding, flows into the Boston Deeps, forming the northern boundary in that direction, to a point near Crowland; and the Nene, which flows southward, until at Northampton it forms a conflux with its western branch, and turns easterly, passing by Peterborough and Wisbeach, also to the Boston Deeps. The Nene forms the southern boundary of the county between Elton and Peterborough. In the Southern Division of the county, rise the southern branch of the Nene; and near Towcester, the Ouse, which passing through Buckinghamshire, Bedfordshire, Huntingdonshire, Cambridgeshire, falls into the Wash at Lynn in Norfolk; and near Weedon, the Cherwell, a tributary of the Thames. There are many minor streams tributary to these the important rivers of Northamptonshire, which is thus intersected by numerous valleys, upon the escarpment of which, owing to the prevalent alternation of pervious and impervious beds, occur the numerous springs of pure water for which the county has a reputation.

It will be seen from the foregoing sketch that the county is fortunate in its mineral wealth—in its iron, its richly-coloured ferruginous and its more excellent oolitic building-stones; its lime, its Collyweston roofing-slates, its brick-clays, its sand, and its gravel. More than a quarter of a century ago, some £30,000 was expended in sinking a shaft at Kingsthorpe, in a fruitless search for coal. Recently, the question of the presence of coal in the county has again been mooted; but to geologists it is an idle question. From the nature and thickness severally of the strata of the nearest coal field of Warwickshire, and of the intervening district, it is not impossible that below the present shaft at Kingsthorpe (967 feet deep) would be found the Trias beds to the thickness of 800 feet, the Permian beds 2,000 feet, and the Coal Measures (before workable coal could be found), 750 feet: a depth in all of more than 4500 feet; being nearly twice that of any existing mine, and reaching far below the point at which, with known appliances, it is possible to extract coal. Moreover, Mr. Hull, F.R.S., Director of the Government Geological Survey for Ireland, who, more than any other scientific man, has made coal and the coal-fields his special study, concludes that the great English coal-field never did extend into Northamptonshire, and that therefore, at any depth, coal cannot be found in the county.

2. An Account of the Eruption of Mount Vesuvius of April 1872.

By J. M. Black, Esq.

The appearance of the mountain during the two or three days after my arrival in Naples presented nothing remarkable, and in no way gave indication of the extraordinary event that was about to happen. In the daytime a small volume of smoke was seen issuing from the summit of the mountain, which at night disappeared, giving place to what resembled a small flame, but which probably was only the reflection of the fiery material within the crater upon the smoke or vapour hanging over it.

On Tuesday, April 23rd, appearances began to change, and a much larger volume of smoke was seen issuing from the summit, and in the evening the brighter reflection upon this column proved clearly that much greater action was at work in the interior of the crater.

Towards the morning of the 24th April (Wednesday) this action increased, and the volume of smoke was considerably augmented during the day, but apparently more towards the Pompeian side of the summit of the cone.

On the evening and night of the same day (24th), the appearance of the volcano was truly grand. Apparently all the smoke had disappeared, and given place to what resembled great tongues of flame, rising up many hundred feet above the summit of the volcano, and the molten lava flowed down the slopes of the Cone in such quantity as to render its progress clearly visible to the naked eye at Naples, a distance of about nine miles. Still, this action did not seem to the observer at Naples to be accompanied with any marked degree of violence, as the lava appeared to overflow tranquilly from the brink of the crater.

The sight, however, almost surpassed description, and the extraordinary and fantastic forms assumed by the fiery lava on the slopes of the Cone, rendered the effect not only grand but fascinating. Interesting as this scene undoubtedly was, it sank into comparative insignificance with what was yet to come, for the lava on this evening was limited in its extent of flow to the sides of the actual cone itself.

It must be borne in mind, in order to follow the description, that there are apparently two mountains, adjacent to each other, and separated by a valley called the Atrio del Cavallo, connected on the eastern side.

On Thursday, April 25th, the mountain appeared to be labouring heavily, as indicated by the rumbling sound that proceeded from the interior, resembling distant thunder. Considerable volumes of smoke were issuing all day from the summit, but it was impossible to perceive, by reason of the Cone being enveloped in vapour, whether the lava was flowing out or not. In the evening of this day, I went as close to the base of the mountain as possible, to have a better opportunity of witnessing the action of the lava, but unfortunately the cone became so completely obscured by clouds of vapour as to frustrate the object I had in view. It was clearly perceptible, however, from my position on the road from Resina, that most violent action was being exerted from within, and the terrible murmurs and trembling of the ground gave sure indication that these tremendous forces could not remain much longer confined. I remained observing the scene till midnight, up to which time these effects were continually increasing, and then left for Naples.

About 6 o'clock on Friday morning, the 26th, it would appear that these great internal actions, of which I had such positive evidence the night before, obtained the release they sought for by rending the northern side of the Cone from the top to the bottom,and extending the rent about 1000 yards into the Atrio del Cavallo below.

From this event, and from the experience of the night previous, I am led to the conclusion that the forces from within had raised a great column of lava to the summit of the cone, which not finding immediate release, had torn asunder the Cone and Atrio by the absolute weight of such an enormous column of molten rock. As soon as the lava, by its outflow into the Atrio had sufficiently reduced the column resting upon these subterranean forces, a tremendous explosion occurred and immense volumes of smoke, charged with bombs of rock (lava), rose some thousands of feet into the air, and assumed for the time the usual pine-tree form characteristic of the usual state of action of this volcano.

Contemporaneous with this explosion was formed, in my opinion the two craters, or rather the single crater was semi-divided by a

wall of rock, as shown in photographs of the interior of the crateral tunnel taken by me soon after the eruption.

At the same time that the northern rent of the Cone occurred, a similar rent took place in the southern side, but not to the same extent. From this southern rent a stream of lava was seen making its way towards Camaldoli, on the south-west side of the Bay of Naples. It happened most unfortunately that about an hour after I quitted the mountain on the night previous, that a large party of strangers and Neapolitans, bent on the same errand as myself, but not deterred by the evident warnings of coming danger, succeeded in making their way past the barrier at the Observatory, and proceeded from thence, it is supposed, up the valley of the Atrio, to about the locality where the fissure opened, with the evident purpose of obtaining a closer and better view of the cone. It is believed, and almost confirmed, that the greater portion of this party, calculated at about 50 persons, were either immediately destroyed by the sudden outburst of the lava, or otherwise roasted by the intense heat, or suffocated by the exhalations proceeding from the rent.

Up to about 9 o'clock of the morning of Friday, 26th April, the smoke continued to assume the pine-tree form, but apparently increasing in volume, and in the velocity with which it was emitted from the crater. After this hour a slight wind sprang up from the eastward, and the vapour gradually lost its pine-tree form, and spread out like an enormous curtain overhead, obscuring the greater portion of the brilliant sky. It appeared to resemble enormous rolls of white carded cotton, one above another, revolving within and without, with just sufficient shade between each to show the enormous space they occupied.

I remained looking at this prospect for hours, and the more I regarded it the more I became enchanted with the scene, which produced the same fascinating effect that the sight of the gigantic falls of Niagara generally do upon the attentive observer of natural phenomena. The column of vapour was four or five times the height of the mount, 4257 feet, and was therefore not less than 17,000 or 20,000 feet, or about three or four miles high.

During the whole of this day (Friday) it was clearly to be perceived from Naples that the action of the eruption was hourly increasing, by reason of the advancing progress of the cloudy vapour, covering, and rising from the surface of the lava streams.

In the valley of the Atrio del Cavallo, at the spot indicated by the secondary eruptive column of smoke, the action seemed to be particularly violent, and frequently this new column varied its appearance by assuming a much darker hue than the main one ejected from the cone. As the currents varied in their courses, the Observatory might be seen from time to time, hemmed in, on its northern and southern sides, by volumes of vapour arising from the lava streams, and its back ground enveloped by the darker clouds emitted from the great fissure in the Atrio. The main stream of lava seemed to occupy the valley between the Observatory Hill and Monte Somma, and known as the *Fossa del vetrana*, and advanced rapidly over the more level and cultivated country towards the villages of Massa di Somma and San Sebastiano lying to the N.W. of the cone. Another lesser stream of lava seemed to flow on the southern side of the Observatory Hill, but apparently much more limited in volume, and to be heading towards the direction of Resina. On the southern side of the Cone again a large stream of lava was descending in a S.S.W. direction towards Camaldoli, fringing that contour by day by cloudy exhalations, and by night by fiery vapours.

Towards the evening, appearances betokened much more violent action, the volumes of vapour increasing, and the thundering murmurs of the volcano becoming more deafening, spreading terror and apprehension amongst all the inhabitants residing in the vicinity of the mountain, and even in Naples itself. Prior to this event the greater portion of the inhabitants of the villages near the volcano had fled, and taken with them their animals and such household property as they could bear away, leaving their dwellings to the mercy of the elements and the rapacity of hordes of ruffians ready to take advantage of this disaster.

The superstitious feeling of the people was excited to the highest degree, and processions bearing a picture or statue of their patron saint of the mountain, San Gennaro, were frequently to be seen; and the reverence paid to any representation of this intercessor proved unmistakably the great faith the unfortunate people placed in his influence. As the night approached the scene became terribly grand and sublime, the impression of which will remain indelibly stamped upon my memory, and all the superlatives in a language of epithets would be hardly sufficient to give an adequate idea of the grandeur of the spectacle.

Immense volumes of apparent flame and smoke belched forth with inconceivable velocity from the summit of the volcano, and rose to the height of several thousand feet, and the lava at the same time oozed out in such profuse quantities from the upper slopes of the cone, as to make it resemble a giant mountain of molten metal. Amidst the great pillar of fire and smoke, gigantic masses of rock, ruby-red in colour, were constantly being ejected to the heights of 5,000 and 6,000 feet or a mile high, and under, and falling on the slopes of the mountain, rolled down with amazing rapidity to the base.

This spectacular effect on the left side was further increased by the activity of the new eruption from the fissure in the Atrio del Cavallo, which was emitting jets of fiery ashes and vapour. To enhance the terror of the scene, must be added the fearful rumblings from the interior of the volcano, resembling the incessant discharges of thousands of pieces of artillery, and the concussions of the air were so powerful as to shake the walls of the buildings several miles distant from the mountain.

What appeared in the day time to resemble advancing columns of smoke became changed as the night closed in to living streams of fire, spreading out for miles on the northern and southern sides of the mountains. These molten streams were constantly being replenished in their bulk and momentum by the gigantic pressure in their rear of new material poured forth from the main craters and fissures in the Atrio. These were burning and destroying everything in their fiery progress, varying their appearances from time to time by sudden flashes of flame caused by the destruction of houses, trees, or other inflammable material within their reach. Judging from my standpoint at Naples, it appeared as though the northern stream had passed the villages of Sebastiano, and was rapidly advancing upon Parra and Ponticelli; while the southern stream had slackened its course, and was apparently stationary about midway between Camaldoli and the mountains.

About 10.30 p.m. of the night of Friday, the 26th, the Eruption appeared to have reached its maximum of activity, and by combining all the effects I have briefly endeavoured to pourtray, it now almost appeared as though the destructive forces of Nature had concentrated themselves into one terrible effort to display their grandeur and intensity.

After this hour the violence of the action began to show evident

symptoms of decline, although the subterranean thunder continued throughout the night with unabated vigour.

The next morning (Saturday, April 27th) the volcano continued labouring heavily, but the pillar of smoke was greatly reduced in volume as compared with that of the day previous. On this day I went to view the lava streams, and was enabled to approach the village of Sebastiano on the N.W. side of the mountain, and distant about three and a-half miles from the cone.

The stream had passed through the village, and wrecks of houses submerged in it could be seen on every side standing above the level of the rocky flood. From a rough estimate of the width of the stream, which appeared to have divided this village from Massa di Somma, I should think it might have been a thousand yards wide, with an average depth of from 18 to 20 feet, and the sides of its banks sloped to an angle of about 60°. The outer crust of this enormous mass had solidified, but the interior, visible through fissures here and there, appeared to be a mass of red-hot material. Fortunately the flow of the lava had slackened after the period of maximum activity reached the night previous, else further destruction of property in the villages of Ponticelli and Circola would have been inevitable if it had continued.

Towards the evening of Saturday (27th) the internal thunder appeared to increase in violence, and in consequence of this circumstance, and a misunderstanding of some reports received from the Observatory on the mountain, an idea got possession of the people that an earthquake was about to happen, and numbers of people, rich and poor, quitted their dwellings, and sought protection in the open country from the impending calamity.

Early the next day (Sunday, 28th) the volcano commenced ejecting cinders and ashes, and, in consequence of the wind being easterly, the sky to the westward of it was obscured by a dark overhanging mass, being the vapour of the crater, surcharged with minute particles of ashes.

In Naples this rain of ashes continued throughout the day, and the ground before sundown was covered to the depth of an inch. These ashes are of a dull grey colour, heavy, and resemble emery powder, and are probably the result of the incineration of old volcanic rock by flame, as the specimens of various conditions of the scoriæ tend to shew, where the stages from the compact pieces to the pulverulent disintegration can be easily recognised.

About noon of this day (Sunday, 28th) I proceeded to the village of Massa di Somma in order to inspect the lava stream from the western side, but a heavy shower of rain having fallen on my journey from Naples, the whole lava sea between the mountain and San Sebastian was enveloped in a mist of condensed steam, caused by the rain falling on the heated surface. I found the lava stream here about 20 feet in height, the destruction of house property considerable, and some wrecks of two-storey stone houses were to be seen, where the walls had been torn away by the advancing column, but, strange to say, no action of fire was visible on the wood work adjacent to the lava.

The country hereabouts was covered to a depth of about three inches with a black volcanic ash, coarser in quality to that fallen at Naples, owing to its being nearer the crater; and there can be little doubt that a continuation of the shower would soon have rendered this village a Pompeii in miniature.

A curious observation was here made during the shower, when, to shelter myself from the rain, I put up my coloured-silk umbrella, and found it was covered in a very short time with a quantity of volcanic ash. It appeared to me that the rain was strongly acidified, and the air charged with some vapour, probably muriatic acid, which made breathing oppressive in it. On my return to Naples, I found my umbrella covered with bleached spots from the same cause, and applying this idea to account for the effects on vegetation during an eruption, is it not reasonable to suppose that the rain is the cause of the destruction of leaves and plants by dissolving the soluble constituents from the ashes before they descend?

Monday, April 29th.—Extract from the telegrams in the "Times," dated Naples, April 29th, 2 p.m.—"Great electric phenomena and flashes of lightning, with vibrations of the earth. Vesuvius still roaring. Earthquakes at Pallina, Nocchia, and Massa. Mountain invisible. Showers of ashes, stones, and sand fell at Naples. Lava had ceased flowing. Projectiles were emitted to the height of a kilometer."

The showers of ashes ceased on Tuesday, the 30th April, and after that all action in the volcano gradually diminished, and towards the end of the week, about May 4th, the mountain commenced to assume its usual aspect, frequent heavy showers of rain having occurred in the interim. The fugitives, gaining confi-

dence, began to return to their properties in order to ascertain the damage the disaster had occasioned, and certainly many of them must have been surprised to find their premises completely buried under a sea of lava. The loss of life is not considered great, and may be estimated at about fifty or sixty persons, including the party on the morning of the 26th, but the destruction of property on the other hand is great, since all the farms and vineyards on the slopes of the mountains have been more or less destroyed.

On Tuesday, May 7th, I ascended the mountain as far as the fissure in the valley between the Cone and Monte Somma, and had an opportunity of witnessing the effects of the late catastrophe. The old path to the Observatory had not been trespassed upon by the lava, but the labour of the ascent was considerably increased by the deep layer of ashes and scoriæ on the road. The vineyards on either side of the road presented a most desolate appearance, and the ruined homesteads themselves seemed to add to the gloom and funereal aspect caused by the smoke hovering about them, and black volcanic ash resting upon every available ledge. The young vines seemed totally destroyed, their leaves curled up, and blackened, and the singed and brittle twigs seemed as if they had passed through a tempest of fire. This calamity happening at so late a period in the season would destroy all hope of a second growth, so that it may be affirmed that the vintage of 1872 would be a total loss. The vineyards on the slopes of Vesuvius are noted for the good wine they produce, generally known by the title of "Lachryma Christi," which is a red wine, and when well made has a good body, and agreeable flavour.

On arriving at the Hermitage, I proceeded along the spur of the hill upon which the Observatory is built, called Mont Cantoroni, walking more than ankle deep in ashes, while before and on either side of me lay the smoking lava, rendered white on the surface by the deposition of salt from the vapours. The first prominent object that attracted my attention was a minor cone, situated about 100 yards or so from the place where the main stream of lava descended into the valley. This cone seemed to have been upheaved from the bed of lava, and in exterior appearance resembled in miniature the great cone before me, and no doubt performed a similar duty in affording vent to the confined gaseous exhalations of the underflowing lava. I was informed that this cone during the

eruption assumed the actions of the larger one by ejecting freely bombs, scoriæ, ashes, and vapours, and may probably account for the dense clouds that were to be seen from Naples issuing out of the Atrio during the day of April 26th. From this spot I proceeded up the Atrio as far as the Great Fissure, which, however, was no easy task, as it was necessary to scramble over heaps of solidified lava, tossed about with every irregularity, with their edges sharp, and cutting, and but feebly blunted by the layer of volcanic ash. From a heap of lava and ash, forming the western wall of the Great Fissure, and distant about 800 yards from the Cone, I was enabled to view the great rent that had taken place on its northern side, extending from where I stood along the valley to the base, and then on to the very summit. The divisions *(crevasses)* of this rent had, however, been completely covered up by the showers of scoriæ and ashes during the latter phases of the eruption. I planted my camera on this spot, with the object of securing the view before me, which was an extremely difficult one to take, no visible object being very prominent—nothing to be seen but ashes and scoriæ—so that much depended upon the effect of shade. I was greatly afraid that the sensitive films I had exposed would have been rendered ineffective from the powerful fumes of burning sulphur arising on every side, but have to congratulate myself that I at least secured the view. The southern and eastern sides of this heap of lava were brilliantly covered with yellow, orange, and white incrustations, consisting of sulphur, and iron and sodium in the form of chlorides, and the small fissures exhaled strong acidulous fumes, probably of muriatic acid. The flow of lava from this fissure and rent had extended to the perpendicular walls of Monte Somma on the north, and east from the base of the cone; and as the fluidified mass rose in bulk, it moved onwards to the spur of the Observatory Hill, and then became divided into the two great streams—the greater one dashing over the Fossa del Vetrana, and the smaller down the valley to the south side of the Hermitage.

On my return to the Hermitage, I skirted round the base of the Great Cone, and at about 200 yards from the Great Fissure perceived a kind of hollow, which may have been another fissure, as its sides were brilliantly coloured by the incrustations of sublimed chemicals previously mentioned.

The next day (May 8th, Wednesday), I essayed and made the ascent of the Cone, and after arriving at the sea of lava, proceeded

from the hill of the Observatory in a southerly direction, and crossed over the new stream that had flowed along its south side in the direction of Resina. This secondary stream was even more rugged than the main one in the Atrio, and its passage laborious to the pedestrian; but this difficulty of the journey being overcome, the ground beyond became more easy, although at each step taken the foot was ankle deep in ashes.

Arriving at the western base of the Cone, and looking upwards not a single projecting point was to be seen on the slope of scoriæ and ashes, but still the ascent did not appear too difficult to undertake, as the inclination of the slope was only about 30°. Every step forward made upon the treacherous bed of ash was reduced by slipping backwards quite two-thirds of this distance, so that in a very short time the task of climbing became very laborious. Add to this, the great heat of the ashes, which were only removed a trifling distance from semi-molten rock, the heat of the sun overhead, the want of a resting place of any kind or firm object to lay hold of, and it may be easily conceived how very anxiously one gazed upwards for the long looked for edge of the crater. Thus struggling onwards and slipping backwards, continued for over three-quarters of an hour on the face of a declivity varying from 30° to 40°, at last a spot was reached where the angle was reduced to about 20°, and where masses of rough lava protruded through the layer of ashes. Another slight ascent at an angle of 30° now remained to climb, and the edge of the Great Crater was reached in about an hour and a quarter from the start from the base of the Cone. The sight I now beheld was well worth all the toil of the ascent; looking westward lay the charming Bay of Naples, with its bright blue waters, the reflection of a brighter sky, fringed on its northern shores by the modern city, and its suburbs, with the islands of Ischia and Procida beyond to screen it from seaward. Along the southern shores of the Bay lay the towns of Castellamare and beautiful Sorrento and numerous villages, and in the sea beyond lay the romantic tower-capped island of Capri. To the northward lay the gloomy valley of the Atrio del Cavallo, encircled beyond by the precipitous cliffs of Monte Somma, and filled with the recent flood of lava, fuming with smoke and dusted with white incrustations, and which stretched away into the two great streams that lay projected before me as on a chart.

To the eastward lay the object of my venture, the Crater of the volcano, which I will now endeavour to describe, from my position at the extreme western side, facing the Bay of Naples. The edge or border at this part was extremely weak; the outer side sloping down at about 30°, and the inner at about 40°, and the rim of the saddle flattened but a few feet across at the top. Looking downwards, it was impossible to see the bottom of the crater, by reason of a series of ledges or steps, projecting from the inner side to a depth say of 80 feet, and at an average angle of about 40°. At my right hand, and on the southern bend, the rim rose abruptly to a height say of 35 feet, forming a peculiar shaped crag, the mass being brilliantly variegated by yellow, orange and white colours, the former preponderating, and causing it to resemble a hillock of sulphur. On the western side, a small fumarole was in action, and at the base a depression was seen, showing the position of the southern rent, which extended thence some distance down the outer slopes of the Cone. At this rupture, the suffocating fumes of muriatic acid were very abundant. and the ground at the surface extremely treacherous. The peculiar shaped crag alluded to descended on the inner side almost perpendicularly, until it rested upon a great rocky wall, sloping towards the centre of the abyss, when it became perpendicular, and so lost to view. The eastern sides of the crater opposite to me appeared almost perpendicular, and dusted by large patches of white incrustations, rendered striking by the brilliant sun. On my left hand, the brink gradually rose to a pyramidal-formed eminence, and was no doubt a craterlet in action at the early stage of the eruption. On the further or eastern side, this sloped off to a deep gap, which marked the position of the top of the great northern rent. The rim of the crater, then rising again, formed two prominent elevations on the eastern border, and swept round to the right to the sulphur crag before mentioned.

Having found, upon inspection, that my position was the most effective to embrace the leading features of the crater, I took a series of photographs, including an angle of about 250°. On the western side of the Pyramid Hill I was enabled to obtain a better view of the abyss, and secured a picture of it by the camera, although, I fear, on doubtful plates. The crater from here appeared to be divided into two great sections by an immense wall of rock, projecting from the elevation facing my first position, and adjoining the barrier projecting from the opposite sulphur hill. This

division appeared to be complete for some distance down, and then was broken by a great arch cut through the wall of rock, and which then became lost to view. Roughly judging, I should have estimated the depth here to be about 700 feet, but being desirous to obtain, if possible, a view of the exact bottom, I proceeded round the sulphur point to the S.E. part of the rim of the crater, where the slope outwards could not have been less than 50°. Approaching the edge of the crater, I lay upon the ashy surface, and looking over into the abyss perceived that the interior slope was almost perpendicular, and the depth probably greater by 100 feet than from my last position, though frequently obscured by mist and darkness. I, however, perceived a sort of crooked pinnacle rising from the bottom to a height of about 40 feet. As I lay here on the brim of the crater, an explosion would occur from time to time, then a volume of vapour would rise, which gradually cleared away, and all again was still.

Facing round to the S.E., a magnificent view opened out before me, as at my feet lay the semi-resuscitated ruins of ancient Pompeii, and beyond the beautiful plain of the Sarno, hemmed in by lofty ranges of hills, crowned by the rugged Monte San Angelo. I then proceeded to view the great northern rent, further round to the north, but nothing more worthy of notice was to be seen, except what I have already described in my view of the rent from the valley of the Atrio del Cavallo below. On inspection, however, it was clear that a great portion of the brim of the crater must have been carried away at the time of the eruption, as the depression of the surface of the Cone was considerable.

Having now completed my inspection, I prepared for my return journey, which, to the uninitiated and inexperienced, appeared accompanied with some danger to person and property. Taking, however, the advice of the guide, to throw the body well back, and drive the heels at each step with as much force as possible into the ash, I commenced to make the descent, and after starting was certainly surprised at the rapidity of my progress. Once on the move, one is compelled for safety to proceed, and at each step made, the weight and momentum of the body caused the ash to give way under the feet, and so down we went, with lightning rapidity, to the bottom of the cone, which we reached in exactly five minutes from the summit, a direct descent of 1,800 feet in height. The deep bed of ashes on the slope secured a

safe descent, but it would be doubtful to say what would happen in descending with this velocity if you were to strike against a projecting piece of lava embedded in it. Possibly, and very probably, you would lose your equilibrium, and be thrown forward, and arrive at the bottom of the descent in a very different manner and condition to what you expected at starting. On arriving at the base of the cone, I made my way across the lava beds to the Hermitage, after a toilsome trudge, and thence drove to Resina, and took train to Naples.

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3. On Some New Crag Fossils.

By Alfred Bell, Esq.

EXCURSION TO PLUMSTEAD AND CROSSNESS.

July 5, 1873.

Directors—Henry Walker, Esq., F.G.S., W. Whitaker, Esq. B.A., F.G.S., and Frank E. Houghton, Esq.,

(*Report by Mr. Walker*).

The party, which included a number of visitors from the Working Men's College Field Club, left the Cannon-street Railway Station for Abbey Wood by the 3.2 p.m. train. The principal object of the excursion was the inspection of the sunk forest-bed which underlies the marshes at Plumstead, and is visible at low tide in the river Thames.

On arriving at Abbey Wood, the company proceeded across the marshes, a distance of two miles, to the ground occupied by the Metropolitan Main Drainage Works at Crossness, admission having been kindly granted by J. C. Bazalgette, Esq., C.B. At this spot, where they were met by Mr. Houghton, the resident engineer, the intention was to take boat and inspect the submerged trees, which are exposed at low water, on the Essex side of the river, immediately opposite Crossness. The tide, had, however, already risen too high for this part of the programme to be carried out, but fortunately another exposure of the forest-bed had been provided for the occasion. By the direction of Mr. Houghton, the marsh had been opened for a depth of eight feet; at this section the buried land surface was well seen.

The section was as follows :—

Alluvial deposit	2 feet.
Yellow Clay	3 „
Blue Silty Clay	3 „
Peat bed, with stools of trees still rooted	—

The succeeding deposits are thus given by Mr. Whitaker, in the details of the Crossness Well-boring in the same marsh :—

Peat with remains of trees	6¼ feet.
Dark-grey Silty Clay	1½ „
Thin layers of Peat and Clay, with decayed wood full of phosphate of iron	1½ „
Dark-grey Silty Clay	2½ „
Silty Sand	2 „
Valley Drift and Oldhaven Beds (?) .	49 „
Woolwich Beds	—

The Members then examined the peat-bed for themselves. Among the stumps and trunks of trees (some of which were of considerable size), the oak and alder were recognised, a catkin of the latter being remarkably well preserved. Mr. Houghton exhibited some articles of furniture made from oak taken out of these marshes during the excavations for the Main Drainage Works.

The forest-bed has a considerable range. "From the bed of the river (in which the peat is found by soundings) the forest passes under the marshes of Kent on the one side, and Essex on the other, where it is concealed by the overlying alluvium, and is only revealed by excavations. The same forest was found under the alluvium in excavating the docks about the Isle of Dogs, and in excavations in Lambeth and Wandsworth marshes.

"During the excavations in Plumstead Marshes for the Southern Outfall Sewer in 1862-3, the forest bed was well exposed.

"Mr. Searles V. Wood, Jun., F.G.S., writes:—

'I followed the forest from Woolwich Arsenal to Crossness Point continuously. Hundreds of trees had been dug out, and were lying on the surface, and we saw some great stools rooted in the gravel. The depth of these stools below the high water mark of spring tides in the river was about 25 or 30 feet, the marsh surface itself being in places many feet below this spring tide level.'

* "Memoirs of The Geological Survey," Part I, p. 460.

'At Dagenham Docks, on the Essex shore, the trench was open some four or five years since, and the section of the forest on the gravel exposed. There was a heap of the peat hard by, and out of this you could pick sprays and leaves of oak as fresh as out of any ditch bottom where they had only laid a year or two.'

"The existence of this Forest bed in the Thames is considered by Mr. Wood to confirm his own original views as to the history of the river. Mr. Wood believes that 'The Thames had formerly no outlet to the area now known as the North Sea, and that the drainage from Middlesex, Essex, and their adjoining counties passed into the Weald, by channels of which three can be traced in trumpet-shaped openings. One of these is at Merstham, near Croydon, another is the valley of the Darent, and the third is the valley of the Medway, the present eastern outlet of the Thames having been effected at a very late period.' Mr. Wood contends that 'The Thames is quite a modern river, and has no connection with either the great gravel sheet or with the Cyrena brick-earths of Grays, Erith, Crayford, Tottenham, Homerton, Shacklewell, &c.; that, in fact, it came into existence as a line of drainage from London to the North Sea only after the elevation and desiccation of the Post-glacial sea-bed of the Weald had put an end to the drainage from Middlesex, Essex, Kent, &c., passing into that area; and further, that the origin of the Thames is coeval with that of the North Sea, which was principally a land area when the Thames gravel was deposited and the sea was over the Weald. The same depression which gave origin to the North Sea during the elevation of the Weald caused the old land valley through which the Thames now runs east of London to sink, giving rise during the process to swamps in which peat accumulated over the forest, until the drainage, finding its way to the sea by this new outlet, the present Thames river became established. Its waters in their natural unembanked state, by depositing the marsh mud, then sealed up and preserved the old land surface. Submerged land surfaces of this period occur at many points of the English Coast, the depth at Grimsby in Lincolnshire being as much as fifty-two feet below high water of Spring tides.' (Quart. Journ. Geol. Soc., Vol. 241, p. 157.) The stretch of this forest-bed in a continuous line across the valley bottom between Kent and Essex, inclusive of the bed of the river, proves,' Mr. Wood contends, 'that whatever difference in elevation there may have been, no land drainage at all approaching in volume to that carried by the Thames, still

less the more copious snow and rainfall of the epoch of the forest, could at this epoch have flowed through the valley now occupied by the Thames east of London.'

"The earliest account of the submerged Forest at Plumstead seems to be that given nearly 150 years since, by Captain Perry, the famous engineer who repaired Dagenham Breach, who describes the fossil trees as 'moor-logs,' the name given by the Thames watermen. Captain Perry gives the species of the trees—hazel and willow—and the mode of their occurrence. A little later (in 1710) an account of the forest as revealed at Dagenham appeared in the 'Philosophical Transactions' from the pen of Mr. Derham, who mentions the names of the following places where he traced this same subterranean forest—Dagenham, Havering, Rainham, Wennington, Purfleet, West Thurrock. Both Captain Perry's and Mr. Derham's accounts are quoted in detail by Dr. Buckland, (Trans. Geol. Soc., 1817, Vol. iv.)

"Remains of reindeer, elk, and ox are found to-day in the forest bed associated with flint implements of the Neolithic period."*

Having been furnished with the above details, the company were invited by Mr. Houghton to inspect a collection of objects taken out of the peat, and some coloured diagrams made from personal observation of the Main Drainage excavations across Plumstead Marshes in 1862. The alternation of horizontal vegetable bands with silty clay was well shown. Some interesting and instructive facts bearing on the origin of sunk forests in river estuaries were given by Mr. Whitaker, who did not agree with Mr. Wood's account of the Plumstead forest-bed.

The Crossness Well-boring was then visited, it being understood that the work suspended in 1869 is about to be resumed immediately. Up to the present time the boring has descended through the following deposits :—

	Feet.
Alluvium of modern Thames, overlying a Forest-bed with Mammalian remains (Post-glacial) . .	22½
Valley Drift and Oldhaven Beds	49
Oldhaven Beds or Woolwich Beds	16
Carry forward	87½

* The paragraphs here quoted are from a circular specially prepared for the excursion by Mr. Walker, copies of which were distributed among the Members. The circular also contained an original section drawn by Mr. S. V. Wood, jun., extending from Bostol Heath across the Thames at Crossness, and as far as Ripple-side in Essex, showing the position of the sunk forest-bed, and the supposed fault at the Crossness Well-boring.

Brought forward.	87½
Woolwich Beds	14
Thanet Sands	32
Chalk	646½
Upper Greensand	12
Gault Clay	148
Total . . .	940

"There is every reason to believe," says Mr. Prestwich, "that the base of the Gault will be reached by prolonging the boring another forty or fifty feet."

Cores of the various deposits obtained during the boring were exhibited by the Engineer, and inspected by the visitors. The bearing of the enterprise upon the question of the proximity of the Palæozoic rocks to the Gault was explained, and particulars of the results of similar borings were given, including those at Kentish Town, Harwich, Ostend, Calais, Hames (near Calais), Valenciennes, Flines Nord, and Mons. The company then returned to Abbey Wood Station for town.

EXCURSION TO MALVERN,

July 21st, 1873, and Five Following Days.

Directors—R. B. Grindrod, Esq., M.D., LL.D., F.L.S., F.G.S.; the Rev. W. S. Symonds, M.A., F.G.S.; and the Rev. Robert Dixon, M.A., LL.B., F.G.S.

(Report by J. Logan Lobley, F.G.S.)

The Members having assembled in the Museum of Townshend House, Dr. Grindrod described his well-known collection of the rocks, minerals, and fossils of the Malvern District. The palæontological collection, although a very large one, consists almost entirely of palæozoic fossils, and is arranged in stratigraphical order. The student is accordingly at once made acquainted with the characteristic species of each formation in the district. Above the cases containing *Cœlenterata*, *Echinodermata*, and *Mollusca*, each of which groups is abundantly represented, a glass-covered case extends along the whole length of the room, and is filled with, perhaps, an unrivalled collection of British Trilobites. Most of the specimens

in this, and indeed in most of the other cases, are marvellously beautiful, and many of great value.

Dr. Grindrod, having concluded his descriptive lecture, conducted the party to the hills. The stones of which the road-side walls are built were, however, so attractive that slow progress was made, the Doctor and his interested followers stopping ever and anon to examine some more than usually fine specimen of syenite or epidote, which had been regardlessly used by the builders, who have unconsciously made these walls answer the purpose of a museum of rock specimens. Gradually ascending, the visitors were charmed with the splendid views they obtained, but they were not thereby allured from the observation of the rocks and the configuration of the hills, the peculiarities of which were noted and discussed. At St. Ann's Well the geologists duly stopped and drank of the pure water of the hills, and soon after they stood on the summit of the Worcestershire Beacon. There, with their geological maps of the district stretched out before them, they surveyed the grand expanse of country around, extending from the Cambrian and Silurian country of the Longmynds and the Ludlow promontory to the Oolitic Cotteswold Hills. Dr. Grindrod pointed out the physical features of the surrounding country, and explained that the Malvern range, consisting of metamorphic syenitic rock, extended N. and S., with, on one side, Triassic strata stretching away to the east, while against the western slopes lay Upper Cambrian and Upper Silurian Rocks, dipping to the west under the Old Red Sandstone, which forms the greater part of the county of Hereford. Though the shades of evening were rapidly darkening, the enthusiasm of the geologists led them to the conglomerate of Miss Phillips, at West Malvern, specimens of which, by the aid of their well-used hammers, they quickly obtained. Thence the way was led round the northern end of the hills until Great Malvern was gained, and welcome rest and refreshment found at Townshend House.

Ledbury and Eastnor.—The train was taken to Ledbury, where the Rev. W. S. Symonds, M.A., F.G.S., of Pendock, assumed the directorship; and, without delay, led the way to the ascending path at the side of the railway. There, Mr. Symonds pointed out that Walls Hill, which was little more than a mile to the west, was capped by the "Cornstones" of the Old Red, the highest strata that would be seen during that day; and that the intermediate vale consisted of the Lower Old Red, the

lowest bed of which they were then standing upon, since, in the adjoining tunnel mouth, the Passage Beds at the top of the Silurians were cut through. The thickness of the Old Red had been ascertained to be in Hertfordshire 10,000 feet. In the lowest beds of the formation at this place *Cephalaspis Lyellii* and *Auchenaspis Salteri* had been found as in the corresponding beds near Ludlow. A little farther onwards an exposure of Aymestry Limestone was seen yielding *Lingula Lewisii*, but the principal characteristic species of the rock, the *Pentamerus Knightii*, is extremely rare at this place. Passing over Dog Hill, a lane section of the Lower Ludlow Shales, exhibiting a decidedly nodular and concretionary structure, was seen, and here Mr. Symonds introduced to the party Henry Brooks, the clever fossil collector of Ledbury. The large quarries in the Wenlock Limestone, on the eastern side of the hill, were next visited; but the heat of the weather was so great and the time so limited that the work done at this fine section was less than under other circumstances would have been accomplished. The *Strophomena depressa*, *S. euglypha*, and fragments of *Phacops caudatus* were, however, found. The director explained the peculiarities of the Wenlock formation, and compared, or rather contrasted, the Wenlock Limestone with the Denbighshire Grits, which he had been lately examining near Llangollen. Continuing eastward past Eastnor, with its stately castle and magnificent park, and traversing Lower Ludlow, Wenlock Limestone, and Wenlock Shale, and crossing a narrow band of Woolhope Limestone, the lowermost formation of the Upper Silurians, the Upper Llandovery, was reached. This formation, called also the May Hill Sandstone, lies unconformably on whatever rocks may be below. Sometimes it overlies one formation and sometimes another, and in this locality the whole series of the Lower Silurian is wanting, the Upper Llandovery being found reposing on, in one place, the Malvern syenitic rocks, and in another the "Black Shales" and trap rocks of Upper Cambrian age. Near Rowick is a roadside exposure of a mass of true igneous rock, one of the outworks, as it were, of the volcanic Ragged Stone Hill, which rears its summit a little to the east; and at the foot of which, in the Valley of the White-leaved Oak, the geologists gladly sought the grateful shades of a thickly-wooded and secluded dell. But rest and shade were not all that were found, for the liberal and kindly Mr. Symonds had provided a luncheon with, what was most appreciated

on this tropical day, abundant cooling drinks. The claims of Science did not, however, admit of long delay, and the fine neighbouring section exposing the inmost rock of the hill, with the "Holly-bush Sandstone," of Cambrian age, super-imposed, was speedily examined. The Ragged Stone Hill was, Mr. Symonds said, the roots of a volcano of probably great elevation, which, in the Cambrian period, and while Cadir Idris was similarly active, poured forth lava and ejected ashes as do the volcanoes of the present day. These ancient volcanoes ceased to be active in the Llandeilo period and previous to the activity of the great Snowdonian volcanoes which commenced in Caradoc times. Now proceeding southwards and skirting Chase End Hill, with Howler's Heath on the west, the Members were brought to an exposure of the Permian Breccia, which lies against the Llandovery of Howler's Heath. A little further south a fine lane section of the Bunter rocks of the Trias, inclined at a considerable angle, reminded the party of the many and great changes and alterations of land and sea conditions, through which the district had passed since the Malvern range first lifted its crest above the waters. The Rev. Reginald Hill had kindly invited the party to visit him at his rectory of Bromesberrow, and accordingly the geologists made their way to his charming and secluded residence, where fruit, wine, and tea, and better still sympathetic friends, awaited them. Leaving Bromesberrow Rectory, the road by Clencher's Mill, where Mammalian Drift was seen, and thence through Eastnor to Ledbury was taken, and the latter place reached in time for the train to Malvern, where the party arrived weary, no doubt, with the excessive heat and the labours of the day, but delighted with the extreme beauty and abounding geological interest of the country they had examined.

Berrow, Pendock, and Tewkesbury.—A pleasant drive of ten miles through the Triassic plain at the base of the Malverns brought the party to Berrow Church, where they alighted and found the Rev. Mr. Symonds, the director for the day, together with the Rev. Reginald Hill, awaiting them. A visit was first paid to the old church, which Mr. Symonds briefly described. James Parker, Esq., F.G.S., then gave a very interesting lecture on the archæology of the sacred pile, preceded by some remarks on the etymology of the word "berrow," which, he thought, was derived from the same Saxon words from which we got "berry" and "wood." The original church was probably

very plain, since very little of an ornamental character remains. The most noteworthy peculiarity of Berrow Church is the absence of a chancel arch, though it is not probable that this almost universal feature was always wanting. Leaving the church, the way was led to a quarry in the Upper Keuper Sandstone, which here abounds with plant remains as well as with fragments of *Ichthyodorulites*, or spines, of the fish *Lophodus*, together with the crustacean *Estheria minuta*, at one time thought to be a mollusc, and called *Posidonomya minuta*. The great number of remains of organisms seen here was a pleasant surprise to the geologists, who, knowing the general palæontological sterility of the Keuper, did not expect to find fossils in the "New Red Sandstone." Mr. Symonds drew the attention of his hearers to the fact that the previous day they had been examining Palæozoic rocks, while to-day they were on Mesozoic or Secondary strata, deposited since the dislocation which had produced the great fault running north and south along the eastern side of the Malverns, and extending to the Bristol Channel. But that all the Triassic land around them had been covered by the Liassic sea, and by Liassic strata, was attested by the Lower Lias outlier of Berrow Hill, not a mile from where they stood. James Plant, Esq., F.G.S., of Leicester, who has specially studied the Trias, described the Upper Keuper Sandstones, which are here quite similar to the beds of Leicestershire. They have a maximum thickness of from 90 to 100 feet, and contain casts of worm tracks, ripple marks, and footprints of *Cheirotherium*, besides the fossils previously mentioned. Some small black spots found in these sandstones, Mr. Plant thought might be particles of coal derived from the Coal Measures, and not of direct vegetable origin as has been supposed. The Upper Keuper Sandstones, though not continuous, have been found over a large area, and they overlie the Keuper Marls above the Lower Keuper Sandstones or "Waterstones." At a very short distance from this highly interesting quarry, the Upper Keuper variegated marls were seen cropping out. These dip towards Berrow Hill, the lower portion of which they form. Mr. Symonds pointed out an old house, Morton Court, at which the famous Cardinal Wolsey, when a young man, lived as chaplain, and then proceeded to relate the legend of the Ragged Stone Hill, whose shadow is said to bring disaster and ruin upon whomsoever it may fall. That shadow had fallen on Wolsey when asleep in the

garden, and hence his last hours were darkened by cruel misfortunes.

Turning from the Keuper with its facts and the old house with its fables, Mr. Symonds led the way to Pendock Rectory, at which he presented his visitors to Mrs. Symonds, Miss Strickland, the sister of the lamented geologist Hugh Strickland, and Miss Jardine, the daughter of the eminent naturalist Sir William Jardine, and after the luncheon which had been hospitably provided for his guests, Mr. Symonds expressed the pleasure he felt in receiving the Members of the Geologists' Association, who were doing work of no small value. A visit was then paid to the ancient church of Pendock, when Mr. James Parker's fund of archæological lore was again drawn upon, and a highly instructive and learned lecture was the result. He rejoiced to find an unaltered church, such as this one was, for modern restorations frequently impair the archæological interest of ancient edifices. Pendock Church, Mr. Parker considered, was of the time of Henry I., and the pointed chancel arch was of the same age as the Norman pillars by which it was supported. The font was probably of the same period, but the tower of the church was of the reign of Edward III. or Richard II., and the woodwork of the seats of the time of Henry VII.

From Pendock Church an easterly route was pursued across the Triassic vale; and after a visit to Pull Court, at which the Members were received by Mr. and Mrs. Dowdeswell, the sections of High Level gravel in the park of Pull Court were examined. In these gravels the tusk of a mammoth had been found; and here Mr. Symonds briefly spoke of the period when the Straits of Malvern existed, and a yacht might have sailed from the mouth of the Severn to the mouth of the Dee. The party then rapidly proceeded through the richly timbered old park to the Tewkesbury road, by which the Severn with its fine section of Upper Keuper Marls was reached. Time did not permit of a detailed examination of the section, the principal features of which are, however, well seen from the bridge crossing the Severn at this point. The coloured bands of the Keuper Marls forming the cliff, at the foot of which the Severn flows, are very conspicuous and in striking contrast to the rich green of the alluvial meadows on the opposite side of the river. After taking leave of their director, the Members returned by train to Malvern.

THE WOOLHOPE VALLEY. — The fourth day was devoted to the Woolhope Valley of Elevation, which, from the time when Sir Roderick Murchison first wrote of "Siluria," has been classic ground to British geologists. The Rev. R. Dixon, M.A., a master of the geology of the district, and the director of the day's proceedings, met the Association party at Stoke Edith Station. At the neighbouring Foley Arms, the room used by Murchison while exploring the Woolhope Valley, was visited with interest, and then the road past Stoke Edith House was taken until Perton was reached. Here the first section was seen. The base of the Old Red is found resting on the Passage Beds representing the Tilestones, Downton Sandstones, and Bone Bed, which overlie the true Upper Ludlow Shales, exposed to a depth of four or five feet, all conformable and dipping to the north away from the centre of the Woolhope Valley. The significance of this section will be subsequently apparent. Following the lane to the south, and ascending to higher grouud, a fine exposure of Aymestry Limestone containing *Pentamerus galeatus* and *Cardiola interrupta* was met with. Passing onwards, and still ascending, the Lower Ludlow Shales are seen to form the banks of the lane, followed by the Aymestry Limestone. Crossing the high ground of Tower Hill the umbrageous woods of Backbury Hill were entered, and presently emerging from their dense shade, the geologists stood on the summit of a precipice commanding the whole of the Woolhope Valley. After stopping perforce to gaze on the magnificent landscape so strikingly and so suddenly opened to their view, they disposed themselves around a space covered with maps and sections, and listened to their director's lecture on the geology of the Valley of Woolhope.

This remarkable valley is elliptical, or rather pear-shaped, and has a dome-like centre higher than the surrounding ground, and the whole is enclosed by two almost complete roughly concentric ridges of higher and newer rocks. It is therefore inferred that the whole has been uplifted by a force acting along the major axis of the ellipse, and that subsequent denudation has removed the rocks which covered those now forming the inner elevations and the centre. All the rocks exposed in the valley are Upper Silurian, while the country outside the exterior rim is composed of Old Red Sandstone, which has been uptilted all around by the uplift of the underlying Silurian rocks. At the Perton

section, previously mentioned, the edge of the encircling Old Red is seen with the uppermost Silurian strata beginning to appear. This section, therefore, gives a clue to the interpretation of the geology of the district. The outer and loftier rim of the valley is formed of the Aymestry Limestone, with an outside slope of Upper Ludlow Shales, and an inside slope of Lower Ludlow Shales. The inner of the two rims is composed of the Wenlock Limestone, with an inside slope of Wenlock Shale extending to a broad band of Woolhope Limestone which nearly encircles the centre dome of Upper Llandovery or May Hill Sandstone, the oldest formation seen. Thus it will be noted that, proceeding from the outer rim to the centre, older formations are met with in regular geological sequence, the hard limestones forming the ridges and the softer shales the intermediate valleys, with a central dome of siliceous rock. There is a prolongation of Ludlow rocks to the south-east, giving to the whole of this Silurian district an elongated pear-shaped form, and as on that side of the valley the strata dip at an angle of only 20°, while at the opposite or north-west side they have a dip of 50°, and even more, Mr. Dixon thought the upheaving force may have acted with less intensity at the south-east, and with increasing violence as it gradually approached the north-west. The symmetry of the valley is not perfect in consequence of a S.W. and N.E. fault occurring below Backbury Hill, and which is suggestively parallel with a line connecting a boss of igneous rock at Lowes Hill and the uplifted Silurian Shucknell Hill. Mr. Dixon stated the summit of the Llandovery central dome covered by Haugh Wood to be 9000 feet above the position it would have had if no upheaval had taken place. The elevation of Haugh Wood above sea level is 570 feet, while the highest points of the outer rim at Ridge Hill, Seager Hill, and Marcle Hill are considerably higher.

Little time was allowed for luncheon, after which the steep Backbury Hill was descended, and passing through the dense plantations of Dormington with their bowery paths, the great Wenlock quarries of Dormington were reached by Mr. Dixon and his followers, who without delay vigorously used their hammers, and soon found themselves in possession of fine specimens of corals, including *Halysites catenulatus* and *Favosites gothlandicus*. Leaving with regret the Dormington quarries, the geologists quickly made their way to the side of the Pentelow Brook, running between

banks of Wenlock Shale, to a point at which is seen a remarkable contortion of Woolhope strata, and thence by the Mordiford Road, past exposures of Llandovery rock to the gorge at the village of Mordiford. From this place the ascent of the central dome was made. A brief examination of the Woolhope Limestone of Scutterdine on the slope of the hill conclusively showed its distinction from the Wenlock Limestone; and at a little greater elevation the Upper Llandovery rock was found cropping out, and thus the centre of the valley of elevation and the geologically lowest rock of the district was reached. Descending the hill, Mordiford was again passed through, and emerging by the gorge from the Woolhope Valley, the party entered the beautiful vale, where the Wye is wedded to the "more lovely Lugg," and the road along the outer slope of the exterior rim and through the fertile vale of the Frome brought the gratified geologists again to Stoke Edith Station, whence, after Mr. Dixon had been duly thanked for his admirable guidance, the train was taken for Malvern.

The Wyche and Colwall.—The weather hitherto, though warm, had been exceedingly favourable for geological explorations, but now came a change, for on the morning of the fifth day of the visit the rain fell so heavily and continuously that departure from the friendly shelter of Townshend House was out of the question. In Dr. Grindrod's museum, however, geologists need not pass time unprofitably; and certainly that wet morning will be remembered as a time when much instruction was given and received. In addition to an attentive study of Dr. Grindrod's splendid collection of fossils, an opportunity was afforded for a meeting of all the Members of the Geologists' Association then in Malvern, presided over by James Plant, Esq., F.G.S., for the purpose of urging the General Committee of the Association to undertake the publication, for the benefit of the scientific world, of the valuable series of palæontological diagrams by the late Mr. Salter, which now adorn the walls of Dr. Grindrod's museum. Soon after mid-day the weather improved, and Dr. Grindrod and his visitors sallied forth to examine The Wyche and the western side of the hills. When the Wyche Pass was reached the rain again fell heavily; nevertheless the ardent geologists continued on their way and, after observing the Upper Llandovery resting against the central ridge of syenite, examined the Wenlock Limestone of the Colwall Copse quarries, which

yielded some good specimens of the usual Wenlock species. The continued downpour of heavy rain necessitated, however, a return to Great Malvern, where the interesting section at the back of the Belle Vue Hotel, showing Bunter Sandstone resting at a high angle against the Malvern syenite, occupied attention for a little time. The party then repaired to their hotel, the Imperial, and after dining together proceeded to Townshend House to attend

THE CONVERSAZIONE.—This meeting had been arranged by Dr. Grindrod for the purpose of bringing together the residents of Malvern and the Members, and a large assembly testified to the interest taken in the visit of the Association. A more appropriate place could scarcely be found for such a gathering than the Winter Promenade of Townshend House. Containing, as it does, both a palæontological and a petrological collection illustrating the geology of the district, and having its walls hung with Mr. Salter's famous diagrams, and other scientific adornments, little was required to adapt the spacious hall to the occasion, but its usual attractions were added to by the exhibition of a botanical collection of great value, which had been brought together by Mr. A. A. Maclean, while, to render the *soirée* still more complete, microscopic objects were displayed in the Library. The contents of the cases having been explained by the Members to the less scientific of the assembly, the visitors were most hospitably entertained in the Great Dining-room by Mr. and Mrs. Grindrod. Subsequently all reassembled in the Winter Promenade, and the chair having been taken by the Vicar of Malvern, the Rev. I. Gregory Smith, M.A., the objects of the Association were explained by Dr. Grindrod, who said he had requested two of the Members to speak on subjects of Geological interest.

Matthew Moggridge, Esq., F.G.S., then described to the meeting from personal observation, the cave at Mentone in which a fossil human skeleton had recently been found. The cave was at considerable height on the hill side, and in it were found the bones of bears and hyænas and other animals now extinct in Southern Europe. What was even more remarkable in the case was that flint implements, undoubtedly made by man, were found, thus showing that man was at least coeval with the animals whose bones had been found in the same deposits as the instruments themselves.

J. Logan Lobley, Esq., F.G.S., was called upon to address the assembly on the Teachings of Geology. He said the task assigned

to him was to give the history of the earth, a somewhat difficult one in the short time at his disposal, but he would attempt what must be but the merest outline of this wondrous history. On the walls of Dr. Grindrod's noble museum there was displayed the injunction "Speak to the Earth, and it shall teach thee." Let us obey this, and question the rocks around the Malverns. But how shall we get answer? Stratified structure and organic remains will reply to interrogatories, and reveal as surely as written language the history of the past. These "records of the rocks," when read aright, will tell us what that old Worcestershire Beacon, possibly some of the oldest land now existing, has seen of the changes on our globe since the crest of the Malvern range first rose above the waters. He then described the origin of one formation after another in ascending order, showing how we are able to establish the relation of rocks to each other in point of time by comparison of the fossil plant and animal remains discovered in their layers. This exposition afforded an opportunity of depicting the succession of animal life from molluscs and crustaceans to fishes, reptiles, and still higher forms of life, which were compared with existing species of the same classes, and illustrated by fossils obtained from the immediate neighbourhood.

The Rev. I. G. Smith, expressed the hearty thanks of the gathering to Dr. Grindrod for his invitation, and to the gentlemen who had delivered such instructive addresses. Marvellous as the revelations of science were, and logical as its conclusions seemed, he hoped they would always look at its teachings with a reverent eye, not leaping hastily to opinions, but waiting for further confirmation, knowing that theories were always changing, and that science viewed aright could not be other than the true handmaid of religion.

The Southern Malverns.—The last day of the Malvern meeting was occupied with an inspection of the geological museum of Malvern College, and a re-examination of the southern hills and the Cambrian rocks of the district, under the guidance of Dr. Grindrod. The Rev. J. A. Panter, Hon. Sec. to the Malvern College Natural History Society, met the party in the Museum attached to the College, which contains a choice, though as yet not large, collection of the fossils of the district. From the College, carriages were taken by way of Malvern Wells to the Herefordshire Beacon. The hill was ascended,

and standing on the ancient British Camp which crowns the summit, the visitors surveyed the hilly and richly-wooded country to the north and west, and then traversed the ridge to the south, passing "The Hermit's Cave," and turning westwards at the head of the beautiful vale opening to Eastnor Park. Soon the Upper Llandovery rock was seen in a lane section, and with a right good will the hammers were used, and not without success, for very speedily *Lingula crumena*, *L. parallela*, and *Ctenodonta Eastnori* were found, and a little perseverance put the workers in possession of many good specimens of these characteristic Upper Llandovery species. With the Obelisk of Eastnor Park on the right hand, the path along the western side of Midsummer Hill was followed until the volcanic hill of the Ragged Stone was gained, when the section near the White-leaved Oak Valley was re-visited, and the "Holly-bush Sandstone," the probable equivalent of the Lingula Flags, closely examined. This is the lowest and oldest unaltered rock of the district, and contains worm tracks and *fucoides*, several specimens of which were quickly found. Descending the hill, a field road was taken, when presently the darkened colour of the soil indicated the proximity of the "Black Shales," the geological position of which has been a subject of dispute. Four species of trilobites—*Olenus humilis*, *O. bisculatus*, *O. scarabæoides* and *Agnostis pisiformis*—have been found in these shales, which have been by different authors correlated with the Llandeilo and with the Lingula Flags. After specimens of the shales for future examination had been procured by each, the geologists left the section and re-assembled in an excavation in a boss of igneous rock near Fowlet Farm, when the thanks of the party were cordially given to the director, who had given much time and attention to the object of their visit, and who had unreservedly opened his most valuable museum during the week. Dr. Grindrod said he had regarded the visit of his brother geologists with great interest, and should always have the most pleasant recollections of the week they had spent together. The Members then returned to Malvern, and, during the evening, departed for their several homes, thus bringing to a close the first visit of the Geologists' Association to the Malvern District.

ORDINARY MEETING, NOVEMBER 7TH, 1873.

HENRY WOODWARD, ESQ., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

Palæontological Papers, by Henry Woodward, F.R.S., F.G.S., F.Z.S., President of the Geologists' Association, &c.; from the Author :—

TITLES OF THE PAPERS.

"Reports on the Structure of the Fossil Crustacea," Nos. 1, 2, 3, 5, and 6.
"On Palænachus longipes" (Oldest known British Crab).
"Notes on the Species of the genus Eryon."
"On a new genus of Phyllopodous Crustacea."
"On Goniocypoda Edwardsi" (New Eocene Shore Crab).
"On Necrozius Bowerbankii" (London Clay Crustacean).
"On Neolimulus falcatus" (Silurian Limuloid Crustacean).
"On Prosopon mammillatum" (OoliticBrachyurous Crustacean)
"On Eurypterus punctatus" (Silurian Crustacean).
"Contributions to British Fossil Crustacea" (Liassic).
"On the Walthamstow Forest."
"On Professor Owen's Restoration of the Pterodactyle."
"Memoir of Professor Sedgwick."
"On Prærcturus gigas" (Old Red Sandstone Isopod).
"On Necrogammarus Salweyi" (Lower Ludlow Amphipod).
"On the Palpus and other appendages of Asaphus."
"Contributions to British Fossil Crustacea" (Carboniferous).
"The Tertiary Shells of the Amazon Valley."
"On Euphoberia Brownii" (Carboniferous Myriapod).
"On some Palæozoic Phyllopodous Crustaceans."
"On some new Lower Eocene Crustacea."
"On Eurypterus Brodiei" (Silurian Crustacean).
"Visit to the Brussels Museum."
"On the Structure, &c., of Trilobites."
"On the relationship of the Xiphosura to the Eurypterida and to the Trilobita and Arachnida."
"On Rostellaria Pricei" (Cretaceous Gasteropod).
"On a new Carboniferous Arachnide."

"Notes on Palæozoic Crustacea" (Merostomata).
"Further Notes on Eocene Crustacea."
"On Encrinurus crista-galli" (New African Trilobite).
"Ancient Stone Implements of Great Britain."
"Notes on Fossil Insect Remains."

All the above Papers by Henry Woodward, F.R.S., F.G.S., &c.

"Maps and Sections of the Superficial Deposits of Essex," by Searles V. Wood, Jun.; from the Author (through Henry Walker, Esq., F.G.S.).

"Quarterly Journal of the Geological Society of London;" from that Society.

"List of Fellows of the Geological Society of London;" from that Society.

"Annual Report of the Belfast Naturalists' Field Club;" from that Club.

"Annual Report of the Warwickshire Natural History and Archæological Society," from that Society.

"Documents relating to the Establishment of Meteorological Stations in India, &c.;" from the Inspector-General of Chinese Maritime Customs.

"On the Distribution of Fossil Insects," by the Rev. P. B. Brodie, M.A., F.G.S., from the Author.

"On the Graptolites of the Arenig Rocks of St. David's, South Wales," by John Hopkinson, F.G.S.; from the Author.

"The oldest known Fossil Butterfly," by A. G. Butler; from Henry Woodward, Esq., F.R.S., &c.

The following were elected Members of the Association:—

John Addy, Esq.; Rev. Cunningham Geikie, D.D.; Douglas George Hamilton Jordan, Esq.; Thomas Northmore Lawrence, Esq., B.A.; William J. Ridewood, Esq., B.A., B. Sc.; William Rossiter, Esq., F.R.A.S., F.C.S., F.R.G.S.; Dr. Philip Lutley Sclater, M.A., F.R.S.; James Stirling, Esq., M.A.

The President, HENRY WOODWARD, Esq., F.R.S., F.G.S., &c.; then delivered the OPENING ADDRESS of the Session 1873-74. See page i., of the present volume.

ORDINARY MEETING, December 5th, 1873.

Henry Woodward, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Winchester and Hampshire Scientific and Literary Society Journal and Proceedings," 1870-1, 1871-2; from that Society.

"Journal of the London Institution;" from that Institution.

"Fugitive Poems," by C. Daubeny, F.G.S.; from James Parker, Esq., F.G.S.

The following were elected Members of the Association:—

Edwyn Godwin Clayton, Esq.; Frank Crisp, Esq., LL.B., B.A., F.L.S., F.Z.S., &c.; Dr. Walter Flight; Henry Fisher, Esq.; Rev. Cosmo Reid Gordon, D.D., M.A., F.G.S.; W. J. Gordon, Esq.; William Abbott Green, Esq., M.R.C.S., F.G.S.; Algernon S. Marshall Hall, Esq.; Edward Jaques, Esq., F.R.M.S.; C. T. Malins, Esq.; C. Gill Martin, Esq.; A. O. Robinson, Esq.; John Ellor Taylor, Esq., F.L.S., F.G.S.

The following Paper was read:—

The Yorkshire Oolites.—Part I.

By Wilfrid H. Hudleston, Esq., M.A., F.G.S., &c.

Introduction.

In offering to your notice this evening a few observations on the Oolites of Yorkshire, I shall be going over ground which has already been well worked, and on which much has been written by eminent geologists. The standard works of Young and Bird, and of Professor Phillips, and the contributions of Williamson, Wright, Leckenby, Morris and Lycett, and many others, to the volumes of the Geological and Palæontographical Societies have already largely illustrated this district. It is not, therefore, claimed for the ensuing paper that it contains much matter which is new, or altogether unknown to many of you.

Physical Geography of the District.

The region with which we propose to deal forms a lobe of elevated land occupying the north-eastern portion of Yorkshire. To the west it presents a series of lofty escarpments, overlooking a broad Triassic plain; and to the east, a series of mural cliffs, overhanging the sea, which thus present magnificent sections of the strata composing them. This mass of land consists entirely

of Mesozoic rocks, from the Lias to the Coralline Oolite inclusive. With the Lias we have nothing to do; but your attention is invited to the extensive and varied series of beds succeeding the Lias, which are known as the Yorkshire Oolites.

The group, viewed as a whole, is essentially arenaceous, and this fact must be borne in mind, lest the term "oolites" should lead persons unacquainted with the district to suppose that we have to deal with a system principally calcareous. It is true, however, that where limestones are developed they frequently assume a type more or less oolitic. Anything like pure limestones, except in the uppermost beds of the system, are rare. Thus, as one walks over the north-eastern moorlands, their general similarity to Millstone Grit districts is most striking; indeed, it is difficult to avoid the reflection that we see about our feet the transported material of the Palæozoic mountains of the North laid out once more in a kind of coal formation, but also, like the Millstone Grit, barren of really useful and workable coal.

Another feature of the system, and one especially applicable to the lower beds, is its extreme irregularity of development; and the very considerable difference which exists between the coast sections and those of the inland valleys and great south and west escarpments, the arenaceous and argillaceous beds of the Lower Oolites being enormously expanded towards the north-east, whilst on the south they seem to attain their minimum. On the other hand, in the south-western parts of our area the limestone beds of all the formations are, as a rule, better developed, and this applies equally to the Lower and Middle Oolites.

Excluding those portions which lie north of the Esk valley, this Oolitic series may be viewed as forming a sort of elongated crescent of high ground, everywhere sloping inwards towards a triangular flat area known as the Vale of Pickering, the mouth of the crescent or horse-shoe being closed by that portion of the Cretaceous escarpment which faces the north, and which stretches across it like the chord of an arc. Following up the idea of the crescent, which, however, is only a rough illustration, as the outline is by no means symmetrical, we shall find that the left horn abuts against the north-west corner of the Cretaceous escarpment, and, as we shall see subsequently, plunges beneath it, under very remarkable circumstances.

Commencing from this position, near the village of North Grimston, at the foot of the Wolds, the Oolites may be said to run

in a W.N.W. direction, in elevations from 300 to 580 feet, as far as Newburgh Park, near Coxwold, a distance of 20 miles, the newest beds being always on the N.N.E. or Vale of Pickering side, and the oldest beds always on the S.S.W. or Vale of York side. This portion or limb of the crescent is known as the Howardian Hills. It terminates suddenly in the promontory of Beacon Banks, near Husthwaite, and we have a gap in the rim at Coxwold, 230 feet above sea level, where there must be an enormous derangement of the beds, as there certainly is a complete change in the direction of the escarpment.*

The escarpment north of Coxwold faces the west, and greatly exceeds in altitude and abruptness the last-mentioned one; but here, again, the lowest beds are outside, or towards the Vale of Thirsk, which is the northerly continuation of the great Triassic plain of Yorkshire, whilst the more recent beds dip towards the Vale of Pickering. The Coralline Oolite, for instance, falls from 1,000 feet on Hambleton Moor to 120 feet near Nunnington, in the Valley of the Rye (the distance being about eight miles), and then plunges under superior beds. On the Hambleton escarpment, as we proceed northwards, older beds are continually met with, being exactly the reverse of what obtains in the Howardian system, until the Great Kildale Gap is reached, which connects the valley of the Esk with the Triassic plain.

North of this great valley some of the Lower Oolites are still to be met with, capping the Lias hills, but these are beyond the district which it is proposed to treat of, and we may accept the Valley of the Esk as the northern boundary of the area under consideration. Between this valley and the Vale of Pickering, the great mass of the Yorkshire Oolites occur; the watershed of the Humber drainage runs along it, varying in elevation from 1,480 feet at Burtonhead to 800 feet at Stow brow, near Peak, on the coast. The length of this mass, measured along the height of land from Ingleby on the west to Peak on the east, is 33 miles. As with the Howardian hills, so also with the Moorland chain, the inner portion consists almost invariably of Coralline Oolite, which is usually viewed as the topmost bed of the system. The exceptions to this will be shown subsequently. These beds have a southerly dip till they disappear under the "so-called Kimmeridge Clay" of the Vale of Pickering.

* The passage, through which the Derwent escapes at Malton, is only 50ft. above sea level.

Young and Bird state that about Helmsley and Kirby Moorside the Coralline Oolite dips with a steady slope a little east of south. Eastward of this the dip is southerly for many miles, whilst at Ayton and Seamer the dip is distinctly S.S.W., till the beds are lost sight of in the vale.

We have seen that the south-eastern extremity of the Howardian system abuts against the Cretaceous escarpment, beneath which it is lost sight of; in like manner the right, or eastern extremity of the Moorland chain, abuts against, or rather is cut off by the sea itself, and thus presents a section, as it were, of a mountain chain, which has been eaten back by marine denudation to its present limits. As this section is mainly in the direction of the dip of the beds, the entire Oolitic series, as developed in Yorkshire, is brought under observation. It may be considered as extending from the cliffs of the Peak 600 feet in height, to where the Middle Oolites finally sink into the sea at Filey Brigg, a distance of 17 miles. In this exposure, commencing from the north-west, we find the Oolitic group resting on the beds which succeed the Alum-shale, and may trace it continuously, with now and then an interruption from fault or intruded drift, as far as the base of the Coralline Oolite; and even a portion of the Coralline Oolite itself is displayed on Scarborough Castle Hill, having been let down by a fault, and apparently thus preserved from destruction. The general dip along the coast from Peak to Filey Brigg is south-east; but in Gristhorpe Bay it is S.S.W., the beds there pointing towards the Vale of Pickering, as seems to be invariably the case wherever they approach within a certain distance of that region.

The Chalk escarpment, whose eastward prolongation terminates in Flamborough Head, completes the circuit of the Vale of Pickering. The interior of this vale is filled for the most part by Kimmeridge Clay, succeeded unconformably, in all probability, by Neocomian clays, and the whole more or less masked by Post-Tertiary deposits.

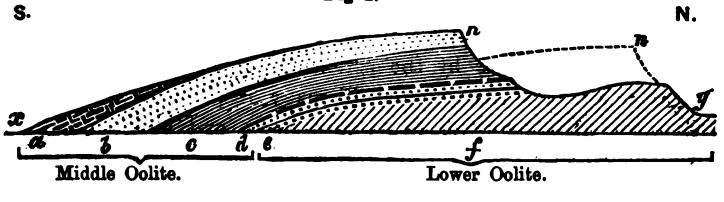
Physical Geography continued.—Region of the Middle Oolites.

Before quitting the subject of the physical geography of the district, it may be useful to note how far the outline of the hills is dependent on the nature of the various formations, and on their stratigraphical arrangement.

The region of what Professor Phillips calls the "Tabular-hills" extends more or less from the coast near Scarborough to the edge of the western precipice at Whitestone Cliff, a distance of 35 miles. In its typical development it consists of sheets of Coralline Oolite dipping rather more rapidly into the Vale of Pickering than the surface slope; hence lower beds keep coming in on higher ground, and the tabular summits consist generally of Lower Calcareous Grit. On these summits the dip is very much diminished as a rule, the beds continuing pretty level to the edge of an escarpment facing the north, where the Lower Calcareous Grit terminates suddenly on a counter slope of Oxford Clay. This tabular system is much cut into by transverse valleys of erosion, whereby the whole is broken up into a series of blocks, forming detached tabular summits, frequently terminating in a point called a "nab." Oliver's Mount, near Scarborough, is a familiar instance of such a nab. These valleys are sometimes dry from the porous nature of the rocks, the streams which they should contain bursting up as springs all along the edge of the vale; others, however, admit the drainage of the interior moorlands through romantic gorges, such as the well-known Forge Valley, where the waters of the Upper Derwent pass out into the vale at the village of Ayton.

Seamer Gap, by which Scarborough is approached from the south, cuts fairly through the Tabular or Coralline Oolite Chain, and to a certain extent discloses its structure, as the annexed diagram, Fig. 1, may serve to exhibit:—

Fig 1.



a. Coralline Oolite of Seamer.—*b*. Lower Calcareous Grit.—*c*. Oxford Clay.—*d*. Kelloway Rock.—*f*. Upper Shale and Sandstone, with Cornbrash (*e*) at top.—*x*. Vale of Pickering.—*y*. Scarborough Suburbs.—*n*. "Nabs." Length of section, 2½ miles.

As the vertical scale is considerably exaggerated, the dip also is drawn in excess, and this applies equally to most of the subsequent sections. The actual dip of the Coralline Oolite at Seamer Quarry is from 3° to 4°, S.S.W. nearly. The Kelloway Rock, which is

an irony sandstone at the base of the Oxfordian, is very variable in thickness, but where well-developed forms a second terrace, as here shown. The Cornbrash, or top member of the Lower Oolites, would lie immediately beneath it.

Taking Hackness as a centre, with a radius of half-a-dozen miles, the Tabular system is most curiously developed in such places as Suffield Heights, Silpho Moor, Langdale Rigg, and the numerous plateaux about Sawdon and the head of Troutsdale. Some of these are natural fortresses, consisting of elevated tables with an escarpment, usually facing the north and flanked by transverse valleys. Where these are not sufficiently isolated by natural causes, artificial earthworks, as Scamridge dikes, attest the uses which an earlier people made of them. It is in these places that some of the great finds of flint implements have been made.

The geological structure of the plateaux is pretty much as exhibited in Fig. 1, and appears to have resulted from a sharp southerly dip of the Coralline Oolite into the vale, whereby the beds of that formation appear to have been preserved, and then a gradual bending over of the Lower Calcareous Grit beds beneath, until these are nearly horizontal. In this condition they reach the northern escarpment, produced by the falling away of the softer beds of the Oxford Clay. It occasionally happens that a portion of the lowest beds of the Coralline Oolite are left on the summits of these plateaux, as is the case on Silpho Moor, and also further westwards on Hambleton, but generally all the limestone beds, together with whatever may have been above them, have been planed away, and their level heath-clad summits consist of beds of Calcareous Grit, so deprived, however, of all calcareous matter by the action of the atmosphere that the result is a rock surface similar in many respects to the regular moorland grits, hereafter to be mentioned, and by many persons confounded with them.

It must not, however, be supposed that this physical structure invariably accompanies the Middle Oolites of Yorkshire. In the Howardian Hills, for instance, there is not much trace of it, although the Middle Oolites are there largely developed. But, generally speaking, where the Coralline Oolite, with underlying Calcareous Grit, occurs, a smooth surface nearly parallel to the bedding is obtained. Hence, where there is a considerable dip, a slope like a glacis is the result, and if the dip alters rapidly either

in degree or direction—as is frequently the case, for instance, between Malton and the Wolds—a very up and down country is thus produced.

Physical Geography continued.—Region of the Lower Oolites.

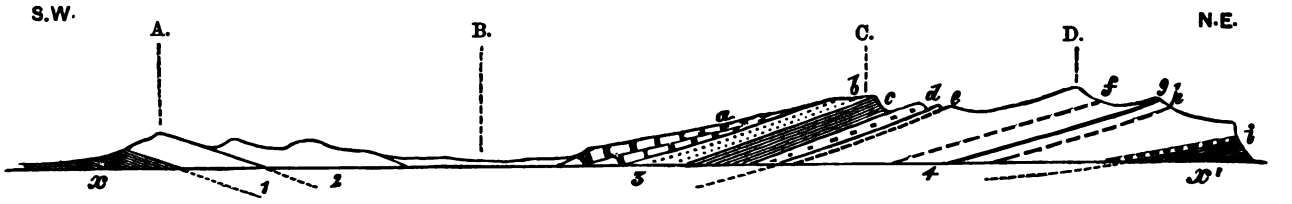
The region occupied by the Lower Oolites, which, be it remembered, consist almost entirely of shales and sandstones, presents a considerable contrast to the one just described. In the district between the Calcareous Grit escarpment and the Valley of the Esk, a roundness of outline prevails amongst the hills, which are usually lumpy, and devoid of any marked contour. As these masses of sandstone and shale occupy the loftiest part of the country the climate does not come to the assistance of a naturally niggard soil. The feeble developments of limestone, containing the fossils whereby alone the age of these great sedimentary beds can be guessed at, make no show on the surface, and are only occasionally to be seen in the transverse valleys running north and south. The country is dreary without being grand, but in the valleys themselves, which are often cut down into the Lias, there occur picturesque, fern-clad banks, alternating with mural sandstone precipices, and ragged woods, which hang over some brawling torrent flowing in the bottom of the glen. Such especially are the lateral gorges on the south side of the great Esk Valley.

In the Howardian Chain, owing to the less copious development of the alternate shales and sandstones of the Lower Oolite, these features are not usually so apparent.

To understand properly the position of the beds of which this region is composed, we must always bear in mind that a diagonal, drawn in a N.E.—S.W. direction from the Lias at Peak to the Lias outcrop facing the Vale of York, would present to us perpetually newer beds until we reach the Vale of Pickering, crossing which we should find the order reversed, until the Lias is once more reached on the opposite or inland side.

The annexed diagram, Fig. 2, may partly serve to explain this; though it must not be supposed that the actual dip of the beds or their relative thickness is therein accurately delineated. It must merely be viewed as a generalized section across the two chains, showing their relations to each other and to the intervening vale.

Fig. 2.



LENGTH OF SECTION 33 MILES. VERTICAL SCALE VERY MUCH EXAGGERATED.

A. Howardian Hills; highest point, about 580ft., near Yearsley, west of line of section.
B. Vale of Pickering; centre about 70ft. above sea level.
C. Tabular Range; highest point about 1000ft. on Hambleton Moor, west of section.
D. Moorland or Watershed Range; highest point, Burton Head, 1480ft., west of section. Burton Head is the highest elevation attained by any Secondary rock in the British Islands.
x. Lias of Vale of York.
x^1. Lias of Robin Hood's Bay, and the Peak.
1. Lower Oolites of the Howardian Hills. } Relative thickness
2. Middle Oolites of ditto. } doubtful.
3. Middle Oolites of the Tabular Range.
4. Lower Oolites of the Moorland Series.
a. Coralline Oolite (including Upper Calcareous Grit) of Pickering.
b. Lower Calcareous Grit of Newtondale, &c.
c. Oxford Clay of Newtondale, and Hole of Horcum.
d. Kelloway Rock of Newtondale, &c.
e. Cornbrash of Newtondale.
f. Grey, or "Scarborough Limestone" of Maybecks, &c.
g. Approximate Geological position of the principal Moorland Coal.
h. Representative of the Millepore Series, traces, as at Danholme.
i. "Dogger" Series of Peak, &c.

The above formations will be described each in its proper place, therefore no more need be said of them *apropos* of this diagram (Fig. 2). It will be sufficient to point out that, whilst the Middle, or Oxfordian Oolites, on each side of the Vale of Pickering, do not differ very materially in thickness, except as regards the extraordinary development of the so-called "Kelloway Rock" in Newtondale; yet the Lower Oolites on the S.W. have shrunk immensely in comparison with their full thickness on the N.E. Still, in spite of this attenuation, some of the limestones are both thicker and better developed as typical Oolites.

Considering, then, some portion of the Upper Lias to be always at the base of the series, we may proceed to examine each formation in ascending order under the two chief divisions of *Lower and Middle Oolites.* Thus divided, all the formations from the Blue Wyke (Peak) Sands, carrying the "Dogger" up to the Cornbrash, inclusive, are classed with the *Lower Oolites,* and all the formations from the base of the Kelloway Rock to the top of the Coralline Oolite are classed with the *Middle Oolites.*

The Lower Oolites.

If we take as our type, the coast sections, which are, in fact, the truncated ends of the beds, as they occur in the main chain, and frequently about their point of maximum development, we recognize a great sedimentary deposit several hundreds of feet in thickness. These beds, though often very full of carbonized fragments, bits of coal seams, and plant remains, are usually believed to be destitute of animal organisms, except in certain zones, which are in some places tolerably fossiliferous. These zones are four in number, and their remains are invariably marine, or, at least, "estuarine." Though generally best developed on the coast, each of these four zones may be recognized in the transverse valleys of the Moorland Chain, or at least in some of them, and, to a certain extent, but with great divergence from the type, in the inland or Howardian Chain.

No. 1.—The Dogger.—The lowest of these fossiliferous zones, although often found in the escarpments both of the Howardian, and Moorland Chains, and in every transverse valley of the latter, which is cut down to the Lias, is, perhaps, the most protean in its character, as in its several designations. To geologists it is known as the "Dogger," or Inferior Oolite, whilst miners always call it the "Top Seam."

To this succeeds some 280 feet of shales and sandstones, as developed at Peak, known as the *Lower Shale and Sandstone*. Above this lies

No. 2.—The Millepore Bed.—This is largely developed as a limestone in Gristhorpe Bay, &c., where it often contains "fragments of Crinoidea, Polyzoa, and the plates and spines of Echinodermata." Nearer Scarborough we find it as an obliquely laminated arenaceous limestone poor in fossils. North of Cloughton it appears in a still more arenaceous form, largely charged with iron, and containing an interesting series of marine fossils. It may be traced as a peculiar irony sand-rock in Peak cliffs, and in one or two places in the interior of the main (or Moorland) chain, notably at Danholme. Dr. Wright correlates the Whitwell limestones of the Howardian Hills with this bed. (See Derwent Valley section.)

Between this zone and the next one, there occurs 100 feet (accepting Cloughton Wyke Cliffs as the type) of shales and sandstones largely charged with vegetable impressions, seams of coal, and occasionally lumps of jet. In this series the celebrated plant-bed occurs. It has received the name of the *Middle Shale and Sandstone*.

Immediately above it there occurs—

No. 3.—The Scarborough or Grey Limestone.—This is a very extensive and variable series. It is feebly developed along with its associated estuarine shales at Gristhorpe Bay, but makes a better show at White Nab, and in Scarborough Bay. Its grandest development is at Hundale Point, five miles north of Scarborough, where it is 50 feet thick, and in parts very fossiliferous. Thence it may be traced, rising in the cliff for many miles, till it goes out a little S. of Peak Hall. Inland it may be traced in several valleys of the main chain, as at Maybecks, Goathland, &c., but nowhere to such a degree as at Hundale Point. In the Howardian Hills the Stonecliff Wood series* is perhaps its equivalent, and likewise the Grey Limestones occurring with the arenaceous masses of Newburgh Park.

Above this occurs the *Upper Shale and Sandstone*, which, on the coast, is well exhibited immediately south of the Spa at Scarborough. Very hard siliceous beds, known in the interior as moor grits, are characteristic of this formation, which is carbonaceous; but not to the extent of the beds below the Grey Limestone.

No. 4.—The Cornbrash.—Resting on these we have the topmost fossiliferous zone. It is well seen at Gristhorpe and Scarborough,

* See p. 329 et seq.

where the Cornbrash proper is generally not more than a few feet thick, being succeeded by about 10ft. of shales, containing a scanty, but somewhat distinct fauna. In Newtondale this Cornbrash is well developed, exhibiting in some places 13 to 14ft. of arenaceous lime rock, but where so very thick and sandy it is poor in organic remains. In the Howardian Hills no representative of the Cornbrash can be made out with certainty.

Proceeding to examine these four fossiliferous zones of the Lower Oolite in detail, we revert to (1) THE DOGGER, and its associated beds. The word "Dogger," in the language of the district, appears to mean any rounded stone, such as is of constant occurrence on the Yorkshire coast, whether derived from some original concretion in the cliffs or otherwise. It is not certain whether this formation has received its name from the lines of nodules, so characteristic of it, or from the peculiar appearance which the rock assumes on first rising out of the sea, owing to the rounding off of the huge oblong blocks, produced by the arrangement of the jointing. Geologists seem to have divided the formation into the Dogger proper, and the sands beneath the Dogger. The former, in its upper part, contains a very rich and well-known fauna, admitted by all to be closely related to the Inferior Oolite. Most of these shells have been procured from the bed marked *e* in Fig. 3. It seems, however, to be a peculiar and restricted assemblage of life not known to occur (so far as I am aware) in any other part of Yorkshire. But there appears to be always a Dogger bed of some sort between the Lias and the Great Sand-rock, though, as in the neighbourhood of Whitby, it is only very thin. The group is always highly charged with iron.

Fig. 3 represents a section of the coast, as it appears from Blue Wyke Bay, with Blue Wyke Point on the left, running out nearly at right angles to the general trend of coast line. Low down on the right the shore line is observed beginning to regain its usual north-westerly trend. High up on the right tower the grand precipices of the Peak, curving almost conformably with the curve of the bay. The result is a magnificent amphitheatre of cliffs, unequalled perhaps in Great Britain for its combination of impressive scenery with the advantages of geological section. None of this, however, is seen in Fig. 3, which includes a little over 100ft. of rock as measured from low water line. Fig. 3 may be called Blue Wyke Point Section. Although less grandiose than the cliffs which continue to rise towards the north-west, this place has

the merit of being more accessible, and it is, to a geologist, perhaps the most interesting spot on the whole coast of Yorkshire.

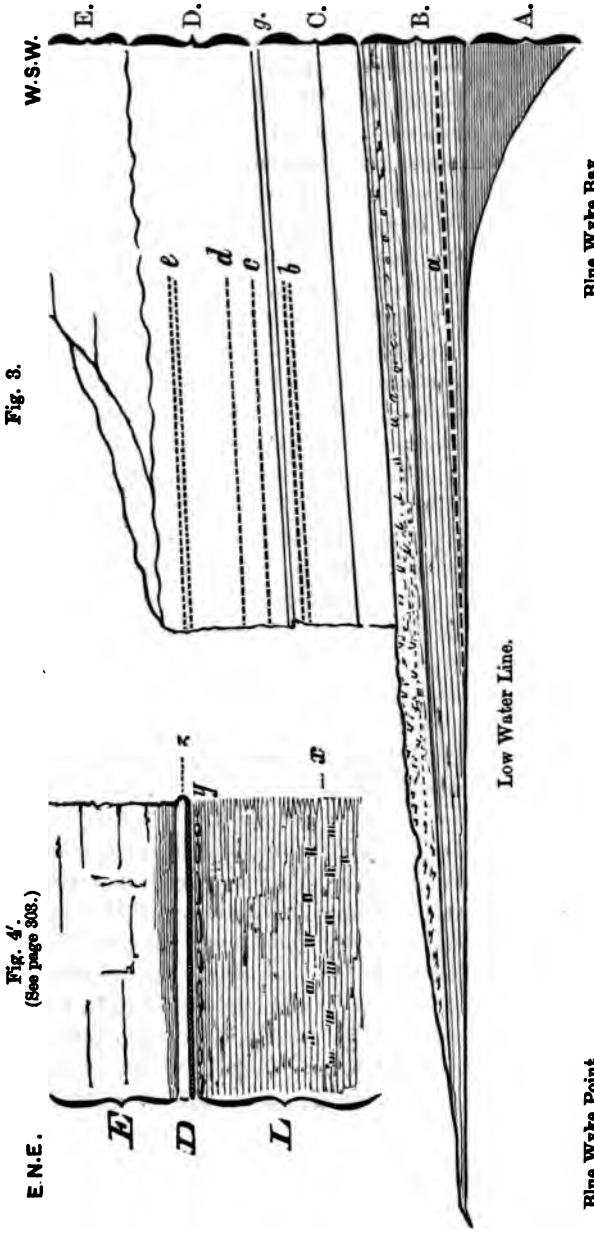


Fig. 3.

Fig. 4.
(See page 303.)

EXPLANATION OF FIG. 3.

A. "Striatulus Beds," top part, the little bay is hollowed out of these beds; no good line of demarcation between these, and

B. The Grey Sands, which, together with the Serpula Bed, forming the top of the Scar, measure about 26ft. This sub-division constitutes the platform on which it is possible to walk at low water; the beds have a south-east dip, and the Serpula Bed forms a low escarpment upon the Scar. The base of the cliff rests upon the latter at the corner.

C. The Yellow Sands, 25ft.

g. A shaly parting between the Yellow Sands and

D. The Dogger; 33ft.

E. The Lower Shale and Sandstone.

a. Main Lingula Bed. *b*. Terebratula Bed. *c*. Lower Nodule Bed. *d*. Upper Nodule Bed. *e*. Nerinæa Bed.

A. *The "Striatulus Beds."*—It will generally be conceded that a geological formation should rest on something. However, the actual base of the Inferior Oolite at Blue Wyke is by no means clear, in consequence of the enormous expansion of certain sandy shales which, though not very unlike the Upper Lias in appearance, have a somewhat different fauna. There is no visible stratigraphical break, and they merely seem to represent the partial continuation of the physical conditions of the Upper Lias with modifications of life-forms such as lapse of time and moderate change of conditions might produce. This would be more especially marked in such organisms as ammonites, always so incontinent of form.

Perhaps the most convenient datum line to take in the Upper Lias at Peak, is the line of *Nucula ovum*, *i.e.*, the 20ft. or so of highly aluminous rock, in which that well-known fossil occurs so plentifully. Above the top of this line at Peak (Blue Wyke Bay) there occurs a great mass of aluminous rock, the upper part of which contains the well known form of *Ammonites Walcotii*. About 20ft. above that a good sized and characteristic ammonite occurs plentifully. It comes somewhat near to the *Ammonites variabilis* of D'Orbigny, though stouter. Some, however, might prefer to class it with *Ammonitis insignis* of Schubler. About the same line as this ammonite I found *Greslya adducta* (Phill.), *Trigonia litterata*, (Y. & B.), also a small *Nucula* of somewhat different form to *N. ovum*. As far as I remember there cannot be much less than 100ft. intervening between the two *Nucula* beds. The next line of ammonites is that in which the *Striatulus* Doggers occur, and hereabouts the characteristic *Ammonites striatulus* (Sow.) is by no means rare. This line is probably 50ft. below the main

Lingula-bed (*a*) of the section, perhaps more. The beds are now grey sandy shales, and this physical condition seems maintained till within a few feet of the *Lingula*-bed.

B. *The Grey Sands.*—The lowest visible bed at the Blue Wyke section is a grey micaceous sandrock, somewhat more argillaceous than those which succeed. It contains, in calcareous irony nodules, small specimens of *Lingula Beanii* (Phill.), together with an ammonite, which has a strong family likeness to *A. striatulus*, but yet is not altogether the same, and some smallish belemnites. The rock is otherwise devoid of lime. A few feet further up occurs the main Lingula-bed (*a* of section), rich in hard irony nests, full of that fossil, in conjunction with *Discina reflexa* (Sow.), and other shells. This lingula pervades the whole of the Grey Sands, but is nowhere so fine as on this line, above which there is from 12 to 15 feet of variegated grey and purplish sandrock. This is well spread out on the Scar at low water for inspection. It is literally studded with belemnites of at least two species.* There are also many specimens of ammonites, both large and small, usually in a fragmentary condition. They lie most plentifully on the top of the lower "lift" of the Grey Sands and just underneath the Serpula-bed. The large fragments usually present a smooth discoidal whorl, which, in the specimen I have before me has a depth, at the maximum, of 70 mm.† About one-third the distance from the interior edge of the whorl the greatest breadth is attained, and beyond this the sides converge, at first gently, and afterwards more rapidly, till they meet in a ridge almost as sharp as a knife. The inner edge of this outer whorl is bevilled off very steeply, and contains within it, what, if found separately, most people would have thought quite a different species—viz., a little strongly ribbed inner whorl, not nearly so sharp in the back as the outer one. This form, and others near to it, are by far the most plentiful. There is, however, another ammonite, now in my possession, said to come from the same place, which may fairly be referred to *A. corrugatus* (Sow.).

The Serpula-bed (upper part of B.), which succeeds, is harder, but of similar composition. It forms the top scar of the Blue Wyke platform, and weathers to a very rough tumultuous surface, owing to the numerous nests of *Serpula* and *Vermetus*, associated

* Dr. Wright, Quart. Journ. Geol. Soc., Vol. xvi., p. 4, gives *B. compressus* (Voltz.) and *B. irregularis* (Schlot.).

† Compare *A. affinis*, V. Seebach, Hann. Jura, t, viii., fig. 4.

with *Avicula* and other shells, all of which are most numerous towards the top. There are a good many shells here, but they are extremely difficult to extract in anything like condition. An immense *Pinna* occurs, and there are also numerous branching forms, which remind one of sponges.

Taken as a whole, the fauna of these grey micaceous sandstones is not particularly rich in Mollusca, except as regards the Cephalopoda, and more especially belemnites, which latter appear to have been particularly abundant. In this respect they present a marked contrast to the majority of the Lower Oolitic beds of Yorkshire. This abundance of belemnites continues into the "Terebratula-bed" (*b* of the section) presently to be mentioned. Besides the other forms already mentioned, *Trigonia Leckenbyi* (Lyc.) was found in the Grey Sands.

C. *The Yellow Sands* are the next in ascending order. At the corner they form the base of the cliff, being worn back by the action of the sea much faster than the harder Serpula-bed on which they rest. They divide into two principal blocks. The first ten or eleven feet consists of a grey-hearted softish sandrock much jointed, and stained yellow by ferric hydrate at the joints. It has fewer sponge markings and serpulæ than the bed below, and seems to be rather poor in organic remains. Fragments of a sharp-backed ammonite occur, however, in the lower part. The upper block consists of about 16 ft. of yellow sandrock, much jointed and roughened externally by sponge-like projections, and other organic forms. The top three feet of this block is chocolate-coloured, like the overlying Dogger, from which, however, it is separated by about 1ft. of shaly stuff. This upper block of the Yellow Sands contains the Terebratula-bed, marked *b* in the Section, which, although coloured like the beds above, must from its position be classed with the sands of the Dogger, rather than with the Dogger proper of this Blue Wyke section, if, indeed, the distinction between the Dogger and the sands which carry it is to be continued.

These upper Yellow Sands contain (irrespective of the Terebratula-bed) a tolerably abundant fauna, mostly derived from nodules and indurated shelly masses, picked up at the base of the cliff as it rises towards the north-west. Amongst others, a very fine *Modiola* is conspicuous.

Crustacea of the genus *Glyphæa*, in very good preservation, are

by no means uncommon. There is also great abundance of a small *Terebratula* which greatly resembles the young of *T. carinata* (Lam.), though perhaps only the young form of one of the species common in the upper beds. *Rhynchonella cynocephala* (Rich.) occurs likewise hereabouts, *i.e.* in the upper part of the Yellow Sands, but below the Terebratula-bed. Belemnites also occur throughout, but of ammonites I have not been successful in finding anything but fragments.

The Terebratula-bed (*b*) is the lowest of four very well marked lines of nodules and shells, which here occur in the cliff, as indicated in Fig. 3. The two centre lines seldom contain anything which can be made out or recognised as having any form, though several of the lumps have the appearance of what is usually termed *coprolite*. In other places real pebbles are said to accompany these curious lumps, but such have never yet come under my notice, and must certainly be rare in the Blue Wyke cliffs. The probability is that these lines represent beds of shells and other organic fragments which have undergone a metamorphic action, more or less complete. In many instances the lumps have a curious resemblance to bivalve shells, such as *Myacites* and *Gresslya* especially. In other cases the lumps can scarcely be fitted to any known form, but a tap with the hammer will at once show that they are not pebbles.

Now in the Terebratula-bed, besides these lumps of doubtful form, there is abundance of a variety of *Terebratula maxillata* (Sow). This species is very different from the one usually referred to the *T. triliniata* of Y. and B., and assigned by Mr. Davidson to *T. ovoides* (Sow.), which frequently occurs in the Dogger somewhere about the line of one of the nodule beds.† The species in this Terebratula-bed (*b*) is not absolutely like the regular *T. maxillata*, but comes nearer to that perhaps than to any other described form. Many fragments of belemnites, and an occasional piece of ammonite, also large ostreæ and many other fossils likewise occur. The shells of *Terebratula* and *Ostrea* appear to have resisted the action which has more or less destroyed the others; or the explanation may be that these genera were the actual inhabitants of the bed into which many of the other forms were projected by currents. About this line the beds become more ferruginous, and the top three feet of the Yellow Sands, which contains the Terebratula-bed, presents an intermediate condition between the real Dogger and the

† My specimens are derived from fallen blocks, and therefore the exact line cannot be determined.

micaceous sandstone beneath. It is beginning to assume the peculiar chocolate hue of the Dogger, although belonging to another block.

(*g*.) A bed of shale, about a foot thick, here parts the Dogger from the underlying blocks. As regards the composition of this bed, it presents the greatest break in the whole series, from the Striatulus-beds (*A*) to the top of the true Dogger (*D*). Nothing but the fragments of a few ostreæ came under my notice in it.

D. THE DOGGER.—We may now proceed to consider what is usually known to geologists as the Dogger. It is well exhibited in the upper part of the section, but is more conveniently examined round the corner towards the S.E., in which direction it dips in such a manner that each bed in succession is brought within reach of the hammer until the whole finally sinks into the sea. Its total thickness here is about 33 feet.

Taken as a whole the Dogger may be described as an arenaceous ironstone; in parts, oolitic. It is thick-bedded, regular, and moderately hard. Commencing from the top the first seven feet contain thinner beds of a harsh gritty texture, much fractured, and infiltrated by seams of brown oxide of iron. Some of these, though rather lean, are workable ironstones, varying from 28 to 34 per cent. metallic iron, but extremely siliceous. Few organic remains have been observed in this division. Then occurs the Nerinæa-bed (*e*., *Fig.* 3), 18 inches thick, from which the bulk of the fossils of this formation have been extracted. The tests are well preserved, though somewhat compressed in a few instances. The original calcic carbonate has been almost entirely replaced by spathic iron, covered by a skin of brown oxide. A partial examination of the shell of an astarte afforded the following results:—Calcic carbonate in small amount, and principally existing in the middle layer. The outer and inner layers of the shell almost entirely replaced by chalybite (spathic iron), which is isomorphous with calcite; the exterior and the partings of the shelly layers lined with an extremely thin skin of a reddish-brown oxide of iron. Prevailing colour of the exterior a brownish-grey, which is the result of the combination of the grey colour of adhering matrix, with this reddish-brown skin. The matrix itself contains very little lime, but much ferrous carbonate along with a little mud, and considerable quantity of sand, it is slightly oolitic, but less so than some of the beds below. In both shell and matrix the iron is almost

wholly protoxide. In most cases the replacement has gone no further than to substitute a salt of iron for one of lime, the form of the shell being faithfully retained. There are also fewer of those amorphous lumps which are so plentiful in the lower nodule beds.

That very experienced collector, Mr. Peter Cullen, declares that *Nerinæa* and *Chemnitzia* occur in the upper part, *Trigonia* and *Astarte* chiefly in the middle, and the shorter univalves at the bottom of this shell bed.

A list of the fossils of the Dogger, principally derived from this bed, is given by Dr. Wright (Quart. Journ. Geol. Soc., xvi., p. 15) from Mr. Leckenby's collection. The following is a list of those exhibited this evening :—

FOSSILS OF THE DOGGER, CHIEFLY FROM BED *e*.

Natica adducta (Phill.)
Chemnitzia lineata (Sow.)
„ sp.
Nerinæa cingenda (Phill.)
Cerithium, two species.
Alaria Phillipsii (M. and L.)
„ sp.
Littorina punctura (Bean.)
Trochus pyramidatus (Phill.)
Nærita lævigata (Phill.)
Trochotoma sp. n.
Acteonina.
Rhynchonella obsoleta (Sow.)
Terebratula perovalis ? (Sow.)
Hinnites velatus ? (Gold.)
Gervillia tortuosa (Phill).
„ lata (Phill.)
Pteroperna striata (Bean. M.S.)
Modiola cuneata (Sow.)
Cucullæa cancellata (Phill.)
Macrodon Hirsonensis (d'Arch.)
Trigonia denticulata (Ag.)
„ V—costata (Lyc.)
„ spinulosa (Y. & B.)
„ sp.
Cardium acutangulum (Phill.)
„ striatulum (Phill.)
Tancredia axiniformis (Phill.)
Astarte elegans (Sow.)
Opis Phillipsii (Mor.)
Ceromya Bajociana (Sow.), vel, C. concentrica (Sow.)
Gresslya adducta (Phill.)

I would direct especial attention to a slab of this rock containing *Nerinæa cingenda* (a very plentiful and characteristic shell), *Alaria Phillipsii*, and *Trigonia denticulata* (an elongated costated form). The trigonias are numerous, and of several species, but decidedly small. The *Costatæ* are represented by two forms, both of which might perhaps be referred to *T. denticulata* (Ag.) There occurs also *Trigonia V-costata*, whilst *T. spinulosa* (Y. & B.) represents the *Clavellatæ*; it is the most characteristic and plentiful of all the trigonias of the Dogger. Amongst the univalves *Natica adducta* and *Trochus pyramidatus* are interesting shells, and there is also a tolerably common *Chemnitzia*, which may perhaps be referred to *C. lineata* (Sow.). Amongst the bivalves *Astarte elegans* (Sow.) is very plentiful; a somewhat similar form seems equally common in some

parts of the Coralline Oolite; there is also the inevitable *Greslya adducta*, which runs through all the Oolites, whilst *Gervillia lata* and *Pteroperna striata* seem confined to the lower zones.

The second Nodule bed (*d* of Fig. 3) contains a few shells, both univalves and bivalves. The third Nodule-bed, *c*, is still less shelly; it contains, however, a very peculiar little *Trigonia*, which although it has some points in common with *T. spinulosa* of the bed above, is yet in other respects very different. There are lumps in bed *c* two inches in length, so that it makes some show in the face of the cliff. Besides these amorphous lumps there are corals, bits of shells, and bodies full of holes that may have been sponges. One of these porous nodules on analysis was found to consist principally of calcic phosphate, ferrous carbonate, a little calcic carbonate, and a little brown oxide of iron. The insoluble residue consisted of a silvery sand, with a little mud. A smooth round nodule, with large oolitic grains inside, was found to be similarly composed, except that the insoluble residue consisted of a fine black mud, which burnt with an empyreumatic odour to a whitish clay.*

It would be too hasty a conclusion perhaps to infer from the analysis of two nodules that they are all phosphatic; yet I apprehend that a more extended examination would only confirm such an inference. The chief difference between these, and the ordinary phosphatic nodules of the beds below the Chalk, consists in the calcic carbonate having been partially replaced by ferrous carbonate. It is evident, however, as previously observed, that those writers who took these things for pebbles were mistaken. That a stray pebble may occur here and there, like the lydian stones, &c., of the Cretaceous phosphate beds, is very probable, but as regards the Nodule-beds of the Dogger at Blue Wyke they must be very rare. A *Terebratula* from the Terebratula-bed, *b*, was found to contain very considerable traces of phosphoric acid, but not sufficiently so as to cause it to be considered phosphatized. This specimen, exterior and interior together, consisted principally of calcic and ferrous carbonates, some oxide of iron, and abundance of sand. An occasional nodule, or shell, occurs throughout the general mass of the rock.

Referring once more to the composition of the Dogger, we find that the block immediately below the chief fossil bed, *e*, contains 38

* These specimens were taken from the third Nodule-bed, *c*, it is believed.

per cent. of metallic iron. Lower down in the series are many beds which look equally promising. A specimen of one of these, a greyish oolite, is exhibited. In structure this specimen is thoroughly oolitic, and yet almost absolutely devoid of calcic carbonate; whilst of ferrous carbonate it contains abundance. The spaces between the ova are frequently filled with a reddish sparry substance, which is probably chalybite, lined with a film of ferric oxide. There is but little grit in this specimen, which is, no doubt, a valuable ironstone, similar to the oolitic ironstone so long worked at Rosedale on the coast.

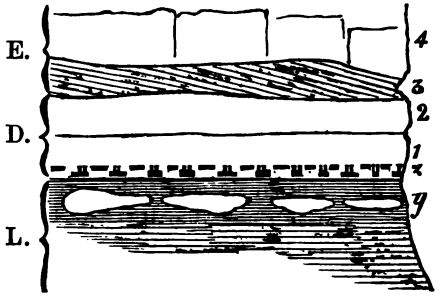
In this case, as in the shells of the *Nerinæa* bed previously noticed, we have a true replacement of lime by iron. The source of this immense quantity of iron, and the cause of its having replaced the lime in these oolitic beds, is at present obscure. Much of it may be due to the action of organic acids, generated from the decomposition of *humus* in the peaty beds above, having dissolved out large quantities of iron from the mica and other basic minerals in the porous sands through which such acids percolated. The ultimate stage of the decomposition of *humus* would be to produce carbonic acid; ferrous carbonate, therefore, in the presence of excess of carbonic acid, would replace calcic carbonate. There are many other points to consider, however, but that the presence of the iron is due to replacement is perfectly certain. The period, when this took place, would most probably be during the deposition of the Lower Shale and Sandstone, which contains even now traces of much carbonaceous matter.

The above is a description of the more obvious features of the Dogger and of its underlying Sands, as they occur at Blue Wyke. All these beds continue to rise in the Peak cliffs towards the N.W., until they are well lifted up by a considerable thickness of Upper Lias. The Dogger, with its shell-bed, seems to maintain its thickness pretty well, though the Yellow Sands in places appear to thicken at its expense. It is not so easy to ascertain if this is the case with the Grey Sands. At the northernmost point of Peak Hill the whole series is thrown out by an extensive fault, ranging nearly N. and S., which brings up the Middle Lias on a level with the base of the Lower Shale and Sandstone. This may be seen about 350ft. above sea level, and 250ft. below Peak Hall, in the northern face of the precipice. Here the beds on the downthrow side of the fault curve inwards towards it. The Dogger

makes a good show in the cliff, and still contains the same shell bed noticed in the Blue Wyke section.

About five furlongs from this fault towards the S.W., the Dogger Series may again be traced well up in the hill, and covered, as usual, by the Lower Shale and Sandstone. Here in the old alum quarries, near Crag Hall, we find it displayed as depicted in Fig. 4*, towards the south end of the line of quarries, and resting upon the regular Alum Shale.

Fig. 4.



L. The Alum rock of the Upper Lias.
D. The Dogger Series.
E. The Lower Shale and Sandstone Series.
y. A line of nodular clay-ironstone of good quality: in places a nodular bed.
x. A Nodule bed at base of the Dogger. *Terebratula ovoides* (Sow). *Cucullæa* sp., Small fragment of an ammonite, ribbed and keeled.
1. Ironstone, rather oolitic, about 2ft.
2. Seamed ironstone, coarse and siliceous.
3. Uncertain sands of the Lower Shale and Sandstone Series, about 2ft.
4. Great Sandrock.

Now let us compare this with what we have already seen at Blue Wyke, on the E. side of the great fault, and distant $1\frac{1}{8}$ mile, as measured on the map. A reference to Fig. 3 will here be necessary. The difference in the development of the Dogger and underlying beds at Blue Wyke and at Crag Hall—nine furlongs apart—is there seen at a glance.

To say nothing of the disappearance of such a large quantity of

* Fig. 4', is a representation of this section on a smaller scale. The comparative section, fig. 4' (See page 294,) is thus explained:—

L. Alum rock of Upper Lias. *x*. Nucula ovum-bed. *y*. Line of clay-ironstone nodules.
D. Dogger, with *x*, Nodule-bed, at base.
E. Upper Shale and Sandstone.

Upper Lias as serves to bring the line of *Nucula ovum* within 30ft. of the Dogger, the whole of the Striatulus-beds, A, the top of which just appears in Fig. 3, are wanting. Fifty feet of the Grey and Yellow Sands, B and C, are also gone, and the Dogger itself, D, has shrunk from upwards of 30ft. to about 4ft. Instead of four nodule and shell beds, *b*, *c*, *d*, *e*, it has only one, marked z in Figs. 4 and 4′, but not by any means to be identified with any of those in Fig. 3. There seems, however, to be a nodule bed of some sort towards the base of the Dogger in most places.

Indeed, it may fairly be said that, between the line of *Nucula ovum* at Crag Hall, Fig. 4′ *x* and the base of the Great Sandrock, E, there is a diminution of at least 200ft. of beds as compared with what obtains in Blue Wyke Bay between similar lines. The greater part of this difference is made up of beds that are entirely missing. No wonder that ammonites are found in Blue Wyke Bay, which do not occur in any other part of Yorkshire. It can hardly be supposed that, the distance being short of a mile and a quarter, this is due to non-deposition. It really looks as if the bed of the Liassic sea was lifted on the upthrow side of the great fault, and thus brought under the influence of denuding currents, or that the downthrow side sank so as to be preserved from such action. It is true that the fault traverses more recent beds, showing it to be long posterior to the period of the Lias. Yet many geologists hold the view that the weak places of the earth are of long standing, and that, when a reaction of the interior upon the exterior takes place at recurrent intervals, such action is apt to be manifested along lines that have already been indicated. The presence of the basaltic dyke, which terminates not far from here, shows, that in times subsequent to the Oolitic, such reaction has certainly taken place in this very district.

Anyhow it is a remarkable coincidence that on the westward or upthrow side of the great fault, there should be such a disappearance of beds in so short a space. The subject, when more thoroughly investigated, may serve to throw some light upon the changes of level and of other physical conditions which marked the close of the Liassic epoch and the commencement of that known as the Oolitic. The presence of so many nodular beds points to that peculiar action, which, towards the close of one set of physical conditions, marks the passage into the other. This seems to have consisted partly in the destruction by marine denudation of muddy

beds somewhat recently formed, and the accumulation, without any great evidence of wave action, of their hardened fossil contents, together with shells which were actually contemporaneous.

Nothing can be more irregular in their developement than the beds between the Lias and the Great Sandrock. In the very next quarry, going northwards, to that where the section, Fig. 4, is taken, the Dogger is already getting much thicker. At Grosmont, high up in the hill, the "Top Seam" has been worked, and is now abandoned as siliceous and unprofitable. It is said to be 15ft. thick. In the next valley of Glazedale, where it was worked formerly, the stone is said to contain a considerable quantity of fossils.

But it is in Rosedale, in the very centre of the great moorland district, that the Dogger, and its associated beds, have yielded the greatest results to mining enterprise. The celebrated Rosedale magnetic ore, of which the heavy dark blue stone, here exhibited, is a specimen, occurs as an enormous boss or local swelling in the Sandrock below the Dogger. On the testimony of the foreman of the miners it exists as a sort of hump or saddle, 600 yards long, by 150 wide, and 80ft. high. It has been "drifted" in all directions during the last 14 years for the purpose of extracting the ore, and is now pretty well riddled. There is nothing like it in all this district, and it may fairly be described as the richest ore in North Yorkshire, a perfect nugget of ironstone on a bare hill side, 700ft. above the level of the sea. Before it was so much quarried and drifted, it used to stand out as a conspicuous cliff, and men hunted foxes into its holes and recesses. There is a tradition, that, during thunderstorms, the lightning frequently struck that cliff of iron; and the country-folks said that treasure must be concealed there, which was true enough, whilst others, more superstitious, thought that the devil lay buried beneath. It is a fact, however, that the magnetie ore was used as a road stone for years by people who took it to be a kind of whin stone or basalt.

The subjoined analysis, by Pattinson, of Newcastle, shows its composition:—

"AVERAGE OF DARK BLUE MAGNETIC."

Water	3·76	
Carbonaceous Matter	0·84	
Phosphoric Acid	1·41	
Sulphur	0·03	
Silica	6 95	
Protoxide of Iron	33·85	48·17 p.c. Metallic Iron.
Peroxide of Iron	32·67	

Carbonic Acid	10·36
Alumina	3·15
Protoxide of Manganese	0·69
Lime	2·86
Magnesia	1·59
	98·16

There are picked samples much richer than this. The two oxides of iron are in equal proportions, which shows at once that the ore is not of the nature of true magnetite, where the proportion of ferric oxide to ferrous oxide is as 69:31. It is probably a partially peroxidized carbonate. The structure of the stone is in parts oolitic, and this fact favours the above view, as we have already seen that these ferruginous oolites hold their iron as carbonate. The practical and valuable feature of the stone is its comparative freedom from silica, the usual drawback to ironstones of this series. The lower portion of the mass, adjoining the Lias, contains less iron. It has quite the features, and contains some of the fossils of the micaceous Yellow and Grey Sands of Blue Wyke. Vacant impressions of the guards of belemnites, with a mould of the phragmocone, sticking up like a pastile in the cavity, are of frequent occurrence. Hence, perhaps, the term "Belmenite" applied by the workmen to this portion of the rock. The magnetic ironstone itself is said to contain no fossils, but its position with reference to the "Belmenite" shows that it belongs to some part of the sands that carry the Dogger, perhaps to the Yellow Sands of the Blue Wyke section.

The Dogger itself is worked as an upper seam in Rosedale, where it is regularly bedded, though of variable thickness. In some new workings not far from the mass of magnetic ore, it is from 12 to 15 feet thick, and divided by 3 feet of irony sandstone. Its mineral character here is just the same as at Blue Wyke, an arenaceous oolitic ironstone; much of it has to be rejected on account of its sandy nature. Very few fossils have been found in it, but I was shown a fine cast of what looked like *Ammonites Murchisonæ*, three inches in diameter, from these workings.

Lower Shale and Sandstone. — In Peak Cliffs these beds are well seen, immediately overlying the Dogger, and having a thickness of about 280 feet, which, so far as I know, is their maximum. They consist of alternations of sandstone and shale, very irregularly bedded, and often highly charged with carbonaceous matter, but, as a rule, contain no marine shells. The

great horsetail called *Equisetites columnare* is found on this horizon. The most remarkable feature of this formation is the Great Sandrock immediately above the Dogger. It is not well seen at Peak, being much split up by shales, but in the valley of the Esk, and its tributaries near Whitby, attains a thickness varying from 50 to 100 feet. Good building stone has been obtained from portions of it. Covent Garden Market, according to Bewicke, is a specimen. Its massive blocks may be seen, like huge Cyclopean masonry, in many of the valleys S.W. of Whitby, where it forms the most romantic scenery. This is the case in the gorge of the Goatland Stream, between Danholme and Beckhole, at which latter place it is observed resting almost directly on the Lias, with very little Dogger intervening. I have already noticed that this Lower Shale and Sandstone group thins out towards the S. and W. of the Oolitic area, but it constitutes a large portion of the Staintondale Cliffs, where, in certain layers of nodular ironstone, many species of fern are very nicely preserved.

2. Millepore Bed.—As we ascend in the sedimentary series marine life is again observed to occur. These indications are but feeble in the Peak cliffs, and in many other localities exist only in obscure and half-obliterated forms. Yet, as will appear in connection with this series subsequently, a closer search might extend the vertical range of at least quasi-marine life, both above and below. I have already indicated the principal exposures of the rock containing these remains, which has received the name of Millepore Bed, from the quantity of a small bryozoan *Cricopora straminea* (Phill.), which is plentiful at Gristhorpe, and occurs more sparingly at Osgodby and at Claughton. The character of this rock at the north point at Claughton Wyke, where it first comes up after its disappearance at Osgodby, is that of a peculiar ferruginous sandrock, not rich in lime, containing one or two bands of ironstone towards the top. The lower of these bands is very fossiliferous towards the base, but the shells are difficult to extract. Some small *Trigonias* have been found here, one called by Dr. Lycett **Trigonia recticosta*, seems peculiar to this horizon. Below this occurs about 7 feet of irony lime-rock, becoming more sandy towards the base, and at the bottom is 14 inches of a shale with ironstone not fossiliferous at the point, but very much so a little further north; the whole measures about 12 feet, but the thick-

* It is extremely characteristic of the Millepore series of Gristhorpe, where it has a vertical range hitherto unsuspected.

ness varies within short distances. The great bulk of the fossils here shown are obtained from an ironstone in the lower part of the series, a little further towards the north. A specimen of the rock is exhibited, and a very remarkable one it is. The fossils have none of their original shell left, nor is this replaced either by calc spar, or by chalybite, but when the rock is fractured, a quantity of a snowy-white powder is found lining the cavity, especially about the hinge area, which seems to replace the shell. It is, I believe, similar in composition to a substance lining the cracks of certain septaria of clay ironstone, which contain the ferns previously alluded to. An analysis, which I made of this last winter, showed it to consist of

Water and organic matter . . .	14·40
Silica	45·98
Alumina	38·22
Lime and Magnesia	1.50
	100·10

hence it is nearly pure kaolin, and must by no means be confounded with either *Scarbroite* or *Allophane*, both of which, though also hydrous silicates of alumina, are very different substances. The rock itself is muddy and ferruginous, partially oolitic in its structure, and contains some grit. The ova and shell fragments appear to be replaced by this kaolin to a considerable extent. There is a very large quantity of carbonate of iron, hardly any carbonate of lime, but there is just sufficient iron peroxidized to impart a reddish-brown tint to the mass. It is frequently charged with carbonized fragments of wood, having the interspaces full of kaolin. The general result is a rock of so peculiar a character, that it might be singled out from amongst any number of other rocks. I believe it to be simply an altered oolitic marl, where the lime has been replaced by iron in the mass, and by the kaolin-like substance in the shelly parts; the formation of this latter is, in some way, connected with the decomposition of vegetable matter.

Occupying, as it does, a position midway between the Dogger and the Scarborough Limestone, it would be natural to expect that its fossils should form a sort of connecting link between these two deposits. How far this is the case, is a question for palæontologists to decide. The fossils, especially abundant, are *Pinna cuneata*, *Modiola imbricata*, *Pholadomya Heraulti*, *P. Sœmanni*, *Lima duplicata*, *Ceromya Bajociana*, besides the *Myacites* running through the group.

The particular fossils are *Pygaster semisulcatus*, *Trigonia recticosta*, and a coral called *Gonioseris*, besides others.

LIST OF MILLEPORE FOSSILS EXHIBITED FROM THE VICINITY OF CLOUGHTON WYKE.

Chemnitzia Scarburgensis ? *M & L.*
Ostrea sp.
Pecten aratus ? *Waagen.*
,, sp.
Lima duplicata, *Sow.*
,, bellula, *M. & L.* (Osgodby).
Gervillia lata, *Phill.*
,, Hartmanni. *Goldf.*
Pinna cuneata, *Bean, M.S.*
,, lanceolata, *Sow.*
Modiola imbricata, *Sow.*
Cucullæa cancellata ? *Phill.*
Trigonia denticulata, *Ag.*
Trigonia small costate species
,, recticosta, *Lyc.*
,, conjungens, *Phill.* or *Lyc.*
,, sp.
Cardium Buckmani, *M. & L.*
Pholadomya Heraulti, *Ag.*
,, Sæmanni, *M. & L.*
Ceromya Bajociana, *Ag.*
Myacites recurva, *Phill.*
,, compressiusculus ?
,, sp.
Pygaster semisulcatus, *Wr.*
Gonioseris angulata, *Dunc.*

South of Scarborough the Millepore bed is brought up by a strong fault running right through the very tip of Osgodby Nab, from whence it strikes across Cayton Bay to Yown Point (Gristhorpe). As a rule the beds are much thicker, and at Gristhorpe Bay more calcareous than further north; here, also, the great mass of the Millepore, *Cricopora straminea*, Phill., occurs. The outermost reefs of Gristhorpe Scar, for upwards of a mile, consist of massive lime and iron-bound rocks, belonging to this series, and, as the purely mechanical deposits are rapidly thinning in this direction, it is very likely that the Dogger, and perhaps even the Lias, are not so far beneath as one might imagine.

In the interior, the typical Millepore bed of Cloughton is not so

NOTE.—Since this paper was read, I have had an opportunity, during the spring of 1874, of examining the *Millepore Group*, as developed at Gristhorpe, and more especially at Yown Point. I find that the whole, to the top of what is usually known as the Third Marine Group, has a thickness of 43 feet, and contains a more or less connected series of Mollusca. *Trigonia recticosta* runs nearly throughout. The Scar itself is about 17 feet thick, and consists of hard arenaceous limestones, sometimes irony, alternating with somewhat looser grit. There are two especially fossiliferous belts in it; the best one is in the bottom Scar, about 4 feet from the base. The top Scar is succeeded by

Fossiliferous marl, capped by nodular ironstone	1 ft.
Argillaceous beds, in which fragments of pentacrinites have been found	8 ft.
Laminated beds, with plant remains in a fragmentary condition ...	5 ft.
Irony sandstone, with nodular concretions, very full of fossils	2 ft.
Grey and brown mottled irony beds of variable character, both sandy and argillaceous—contain *Trigonia recticosta* (Lyc)	7 ft.
Sandrock, terminating in a very irony bed full of fossils	3 ft.

This last is within a very few feet of the plant bed.

When we reflect upon the great thickening of this series towards the south, and bear in mind its relation to the Whitwell Oolite, presently to be mentioned, it seems probable that the Millepore Group is more likely to represent the Cave Oolite, and consequently the Lincolnshire Limestone, than does the Scarborough Limestone, which is thinning amazingly in this direction.

readily detected, owing to its variable character, and its general tendency, as developed northwards, to pass into a ferruginous sandstone. I have found it, however, very fairly exhibited at a beautiful little waterfall in a tributary of the Goathland stream near Danholm.

At this spot the water of the little beck is precipitated about 14 feet into a picturesque caldron usual in such places. The section thus afforded, commencing from the top, exhibits the following beds:

Indurated flaggy sandstone, charged with iron . . .	3 ft.
Soft shaly stuff	3 ft.
Peculiar Sandrock containing impressions of *Modiola*, and especially of *Pholadomya Sœmanni*	3 ft. 6
Sandstone to base of fall	4 ft. 6
	14 ft. 0

The representative of the Millepore Zone in the Howardian Hills will be described subsequently.

The Middle Shale and Sandstone succeeds to the above. This is the principal carbonaceous group of the Lower Oolites. In the little valley near Danholm, just alluded to, the main coal seam is about 15ft. above the last-mentioned fossiliferous bed. Here it is about nine inches thick, all included, and only the middle portion is good for anything. It has been worked at several places during the last winter by men who got out a few sacksful at a time when they had nothing else to do. This coal is of little economic value, but is remarkable for its persistency over a very large area, extending from the coast inland as far as Castleton in the N.W., and Coxwold in the S.W. of the main chain. It is said never to exceed 18 inches in thickness, and is in general about 10 inches. That a bed no thicker than this should yet maintain itself over such an extensive district points to a remarkable uniformity of conditions throughout a great part of the area now occupied by the Yorkshire Oolites at the period of its deposition.

I must again refer to Cloughton Wyke in order to explain the general relations of these middle "estuarine" beds, which are in that locality just about 100ft. thick. We observe here a perpetually recurring series of softish yellow sandstones and greyish shales, interspersed with thin seams of coal, fragments of trees converted into a brittle kind of jet, and beds containing plant remains. The sands and shales come in and go out within short distances, but certain beds are persistent, and may be recognised in

the interior of the country, such as the coal bed, the flagstones in the centre of the series, and the great sandrock at the top. The whole is usually described as destitute of animal remains, but I have found the impression of a small *Pteroperna* in the great sandstone, together with the casts of a small *Ostrea*, and a shell something like *Quenstedtia* at the base of the same rock, and have little doubt that a careful examination would disclose a much larger fauna than is usually supposed. Vegetable remains are extremely plentiful; in some of the more false-bedded sandstones we observe large pieces of what was once timber lying in certain basins mixed with the leaves of *Zamia*, and the roots of *Equisetites;* the timber is often converted into jet. Ironstone nodules are of frequent occurrence in such places. The chief plant bed is in a shale rather lower in the series. At Gristhorpe the plant bed has yielded a well-known suite of cycads, and of ferns of the genera *Sphænopteris*, *Pecopteris*, *Neuropteris*, &c. It is not proposed, however, to dwell on the botany of this group in the present paper, and, therefore, we will pass on at once to

No. 3. The Scarborough Limestone.—This is an important series of marine and estuarine beds, known as the Bath Oolite of Professor Phillips, or the Grey Limestone of Dr. Wright. Its localities have been already partially indicated, and it only remains for us to consider its special features and organic contents.

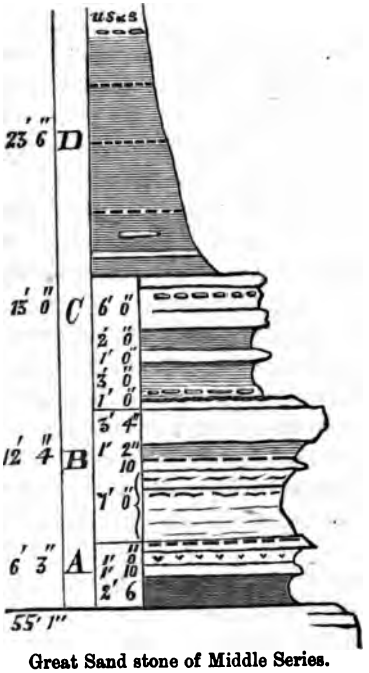
Although exceptionally developed at Hundale Point, on the south side of Cloughton Wyke, there is no place which affords a more convenient section, though a study of that section alone might give an exaggerated notion of its thickness and importance. It would seem that each of the fossiliferous zones of the Lower Oolites, the Cornbrash excepted, culminates at some point on the coast where the group is thicker and more fossiliferous than anywhere else. This is, no doubt, due to the circumstance that, where there has been an unusual assemblage of organic remains, such beds are more largely charged with salts of lime and iron, whereby they are indurated and made capable of resisting the action of denudation.

It must not be supposed that this group is essentially oolitic in its structure. Indeed it would seem to be the least oolitic of the four fossiliferous zones of the Lower Oolites. Lithologically it consists, for the most part, of blue and grey limestones, more or less charged with dark-coloured mud. Sometimes this latter is in such excess as to form a sub-calcareous indurated shale, or mudstone, and

sometimes a hard shale nearly destitute of lime. The purer limestones, especially those of the lenticular concretions and bedded layers, are sub-crystalline. This general bluish grey colour is probably due to the presence of iron in some form, aided perhaps by carbonaceous matter, which retards oxidation, and the same rule may apply to what are called blue-hearted limestones, so frequently met with in Oolitic rocks. This group also contains abundance of both nodular and bedded ironstones, but either the quality is not good, or the stone is too lean, for no one at present works it, although there is a considerable mass of ironstone on the Scars immediately south of Scarborough. Subjoined is a description of the series as it occurs at Hundale, illustrated by an explanatory section, Fig. 5.

At Hundale the beds appear to divide themselves into four groups, which in ascending order may be stated as follows:—

Fig. 5.



Great Sand stone of Middle Series.

EXPLANATIONS.

A. The lower fossiliferous zone, characterised by *Cucullæa cancellata*, *C. reticulata*, *Pteroperna plana*, a small variety of *Pecten lens*, and towards the base by great numbers of myaciform shells—6ft.

B. The great Scar Limestone, with its underlying mudstones, &c.—12ft. 4in.

C. The upper and principal fossiliferous zone, consisting chiefly of hard grey marls and limestones, with *Trigonia costata* (Sow.),* *Perna rugosa*, *Ostrea flabelloides* (Lam.), *Pinna cuneata*, *Gervillia acuta*, *Avicula Braamburensis* and the shorter form of *Belemnites giganteus*—13ft.

D. Marly shales, containing, towards the base, the larger form of *Belemnites giganteus*, and indurated shelly masses charged with *Avicula*, *Cardium*, *Isocardia*, and *Cerithium*, all extremely small. Further up occur at intervals masses of compressed aviculoid shells, and at the top a line of iron-stone nodules with *Avicula* —23ft. 6in., making a total of 55ft.

* The *Costatæ* are here represented by some very fine, well grown forms. It is, however, probable there may be more than one species. Subject to correction the *specific* name *costata* is here retained.

This figure is constructed from actual measurements of the beds as they rise on the shore towards the north-west, each bed being measured in its most accessible and convenient position. Hence as these vary very rapidly within short distances the entire group at any given line on the cliff might yield somewhat different results. The measurements thus taken are then put together, and the section drawn pretty much as it appears in the cliff north of Hundale Point, just where the Great Sandrock is well out of the water. Hence, allowing that some of the beds are a little diminished, there cannot be less than 50ft., which may fairly be referred to the Scarborough Limestone.

Described in detail the beds are as follows :—

A. 2-*ft.* 6-*in.*—Rubbish and black shales immediately overlying the Great Sandrock.

1-*ft.* 10-*in.*—Bluish mudstone with small *Gervillia.*

1-*ft.*—Bluish shaly marl charged with *Myacites, Greslya, Pholadomya,* &c., usually in an imperfect condition.

11-*in.*—The Lower Iron Scar; very fossiliferous, but shells splintery. This is a fine-grained, grey ironstone, with a few dark oviform grains. The shells already named come from this bed with several others.

B. 7-*ft.*—These are very variable beds. Towards the bottom they consist of blue micaceous mudstones, occasionally hardened by lime, and much traversed by what appears like vermiform markings. In the upper part are some very fine ripple-marked slabs, and sometimes above these are courses of hard, blue, siliceous limestone. The thickness varies.

10-*in.*—The Upper Iron Scar, with shale at the base, contains only a few *Aviculæ*; composition like the one below.

1-*ft.* 2-*in.*—Soft blue mudstone.

3-*ft.* 4-*in.*—Hard, grey, flinty rock, sometimes a calciferous grit. Not obviously fossiliferous. This bed, often capped by a portion of the one above, is the most durable and persistent in the whole series, forming scars along the beach, and walls of rock, by which it may be traced, in the cliffs. In cases where the beds immediately below become harder, the whole sometimes unites into one or more blocks, forming a mass of considerable importance. It may be regarded as the back bone of the Scarborough Limestone, towards the middle of which it occurs.

C. 1-*ft.*—A hard variegated mudstone, calcareous in parts,

with many vermiform and spongeous markings. Towards the top contains *Serpulæ* and the spines of *Echinites*. Part of this rock is very hard, and often caps the Scar-limestone.

3.-*ft.*—A blue variegated mudstone, calciferous in its lower parts, where, in limestone nodules, very fine specimens of *Trigonia costata* may be obtained.

1-*ft.*—This is the lowest bed of the peculiar grey, impure limestone, which is so very fossiliferous. This particular band contains *Serpulæ*, with *Avicula Braamburiensis*, and occasionally *Perna rugosa* and *Ostrea flabelloides* (Lam.).

2 *ft.*—Soft variegated shale, with but little lime—*Serpulæ*.

6-*ft.*—Grey, impure limestone in two or three beds, with a line of limestone "doggers," *i.e.*, lenticular nodules, in which very fine specimens are obtained. Here *Pinna cuneata* is observed in its upright position, just as it lived. A large portion of the Scarborough Limestone fossils come from these beds. Besides those already mentioned, a finely-marked clavellate *Trigonia*, referred by Dr. Lycett to *T. signata* (Ag.), is sometimes found. *Myacites* and *Greslya* are again abundant.

D. 23-*ft.* 6*in.*—The lower portion of these shales is very seleniferous; there appears to be a good many fossils just at the base, but their condition is against their being much sought after. About three feet up is the zone of the larger form of *Belemnites giganteus* in blue seleniferous shale (poor in lime carbonate). The *Aviculæ* seem to diminish in size upwards, as if the conditions were more unfavourable. The ironstone nodules denote another change of conditions; above these the shales are devoid of lime and of organic forms, and about three feet higher the Upper Sandstones set in fully. In this manner the series of the Scarborough Limestone, at Hundale, dies out.

The above four groups may be more or less recognised throughout the Staintondale cliffs. The upper part of the second group (B of Fig. 5), from its superior hardness, is the most conspicuous, and guides the eye as it endeavours to pick out the Grey Limestone Series from amongst the heavy, and almost equally grey layers of sandstone, which form the principal masses of these cliffs.

FOSSILS OF THE SCARBOROUGH LIMESTONE EXHIBITED. (PRINCIPALLY FROM HUNDALE.)

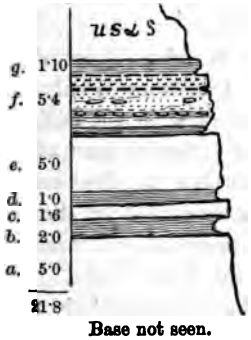
Belemnites giganteus (Schlot.)
" " var.
*Ammonites sp.
Chemnitzia Scarburgensis (M. & L.)
Cerithium Beanii ? (M. & L.)
Ostrea flabelloides (Lam.)

Pecten lens (Sow.)
„ clathratus ? (Römer)
Avicula Braamburiensis (Sow.)
Gervillia acuta (Sow.)
Perna rugosa (Goldf.)
Pteroperna plana (Lyc.)
Pinna cuneata (Sow.)
Modiola imbricata (Sow.)
„ cuneata (Sow.)
Cucullæa cancellata (Phill.)
„ reticulata (Phill.)
Trigonia costata (Sow.)
Trigonia signata (Ag.)
Isocardia nitida ? (Phill.)
Unicardium depressum (Phill.)
Quenstedtia lævigata (Phill.)
Pholadomya Heraulti (Ag.)
Myacites calceiformis (Phill.)
Myacites, one or two species.
Mya æquata ?
Gresslya peregrina (Phill.)
Univalve sp.
„ sp.
Vermicularia nodus (Phill.)

* Since obtained—Ammonites Humphresianus (Sow.), and A. Blagdeni (Sow.).

On the shore south of Scarborough the Limestone series is very differently developed. Here, after passing the anticlinal of Ramsdale Scar, the beds are lost sight of for awhile, being depressed into a shallow trough, which is filled in with the Upper Shale and Sandstone. Presently the top beds are seen to re-appear, and thence form the coast scar as far as White Nab, where they are lifted up a little and well shown, about 22 feet being exposed. (See Fig. 6.)

FIG. 6.



Base not seen.

EXPLANATION OF FIG. 6.

a. The bottom rock seen here, as far as the tide permitted on the occasion of my visit, is a hard block limestone. It is generally supposed to be about 12 feet thick, though no more than five feet is usually seen.

b. 2-*ft.*—A bluish-grey mudstone, known as the Lower Belemnite-bed.

c. 1-*ft.* 6*in.*—Hard siliceous limestone, similar to *a.*

d. 1-*ft.*—Bluish-grey mudstone; the Upper Belemnite-bed.

No *Trigonia* or *Pteroperna* has been found in any of these beds, or those above them.

e. 5-*ft.*—Hard, bluish-grey limestone, used for construction of pier; *Chemnitzia.*

f. 5-*ft.* 4*in.*—The Ironstone Series, divided into several distinct beds, containing different sets of fossils.

No. 1.—(From the top) 18in., grey and brown, ferruginous, sandy marl, full of *Avicula Braamburiensis*, and of various branching forms in the condition of ironstone, with much nodular and bedded gritty ironstone towards the top.

No. 2.—6in.—Is a bed of compact flinty ironstone full of *Gervillia acuta.*

No. 3.—This is a block made up of courses of dark indurated marly shale alternating with gritty ironstones. It contains specimens of *Avicula Braamburiensis*, much finer than those above.

No. 4 —Generally in the same block as the last, occurs a line of dark mudstone, containing saurian remains, and having towards its base nodules of ironstone, in which *Ammonites Blagdeni* has occasionally been found, not however in this precise locality.

No. 5 —At the base of the block is a softer bed, in which an occasional ammonite and belemnite with *Ostrea flabelloides*, occur.

g. 1 *ft.* 10 *in.*—Grey and yellow marly shale, crammed with *Avicula Braamburiensis*. Towards the top of this slaty tables sometimes occur, containing an occasional star-fish, *Serpulæ*, encrinite fragments, and spongiform bosses. With these are found fragments of wood, and a few small *Gervillia*. Total thickness of bed seen, 22 feet.

Above this, is a fine-grained yellow sandstone, containing in its lower parts casts of very small *Aviculæ*, and thus the series dies out at White Nab.

On comparing the two exposures at Hundale and White Nab, their difference of development is striking. The chief features at White Nab are the extent of the Ironstone Series in the upper part, and the small thickness of the shales. It is not at all improbable that all the beds here, above the Upper Belemnite-bed, are on the horizon of the shales at Hundale, and therefore higher in the series than the bulk of the Hundale beds. With regard to the base of the series, no actual comparison can be instituted, as we cannot reach the bottom at White Nab ; but on going two or three miles further south a still greater change is noted.

In Gristhorpe Bay, according to Dr. Wright (Quart. Journ. Geol. Soc., Vol. xvi., p. 29), "the Grey Limestone is only three feet in thickness, and may be easily overlooked in the cliff, if it happens to be covered by *debris*." In the extensive scars of that bay, some distance inside the Millepore-bed, a long reef may be noticed parallel to the latter. This is partly caused by the great sandrock which carries the Scarborough Limestone, and inside this scar is a lane of water, only dry when the tide is well out.

This lane represents the position of the *Avicula*-shales, which have been partly washed away. I found here some of the typical shells of the series in bad condition, viz., *Avicula Braamburiensis*, *Trigonia costata*, *Ostrea flabelloides*, *Gervillia acuta*, and a small *Ostrea*. The real thickness of the group, under such circumstances, is difficult to estimate, but if we accept Dr. Wright's measurement, the Scarborough Limestone has shrunk in a distance of eight miles from 50 feet at Cloughton (Hundale), to three feet at Gristhorpe. The Millepore series, on the contrary, which is divided from the Scarborough Limestone by the "Coal Series" or Middle Shale and

Sandstone, shows a great increase of development at Gristhorpe, and is also infinitely more calcareous than further north. Thus it may be said of the two middle fossiliferous zones of the Lower Oolites of Yorkshire that the lower one increases towards the south, whilst the upper one gives indications of going out altogether in that direction.*

The exposures of the Scarborough Limestone in the escarpments and transverse valleys of the interior are of great interest to the Geologist, as affording a definite horizon to work upon. In the moorland district they have, in former times, also afforded the agriculturist a moderate supply of lime; but as great skill was required in selecting and burning these impure limestones they are now seldom worked. A single instance must suffice.

In Maybecks, which is one of the glens on the south side of the Esk, the series is cut through by the moorland stream, about 450ft. above sea level. The hard, flinty limestone or Scar-rock is here from two to three feet thick. Below this are some beds of calcareous rock, but no traces of the lower fossiliferous zone of Hundale were made out. Above the Scar-rock it is easy to recognise the upper fossiliferous zone in the hard, grey marlstone with *Gervillia acuta, and Avicula Braamburiensis. Ostrea, Astarte,* and a large *Lima* were also observed, but all in poor condition. Fourteen feet of grey marly shales succeed with crushed aviculoid shells, and then 4ft. or 5ft. of very fine-grained flaggy sandstone, containing the impressions of various myaciform shells along with *Avicula* and ribbed cylindrical forms of vegetable origin. These latter beds seem to belong to what is called the "Upper Shale and Sandstone." Every trace of lime has been removed from them.

* Since the above was read, I have had an opportunity of noticing with greater attention the Gristhorpe section.

The Scarborough Limestone series there cannot be less than eight feet thick, including, of course, the Grey Marls or Shales, with *Avicula* at the top. The lower part consists of the characteristic impure Grey Limestones, and is tolerably fossiliferous. *Belemnites giganteus, Trigonia costata,* &c., are plentiful, but in bad condition. I found also a *Terebratula*—probably *T. maxillata*—the only brachiopod I ever obtained from any portion of this formation. The lower half of the great series at Hundale evidently has no representative here.

Viewing the great attenuation of the Scarborough Limestone series at Gristhorpe in conjunction with the expansion of the lower fossiliferous zone (Millepore-bed), my original opinion, that the former goes out altogether towards the south, is much strengthened. It may perhaps, through the thinning out of the Middle Shale and Sandstone, ultimately coalesce with the Millepore-bed. There is very good reason, however, judging from a North Yorkshire standpoint, for supposing that the Millepore-bed, and its inland equivalent, the Whitwell Limestone, are, in this part of the country, the chief representatives of the Inferior Oolite limestones obtaining further south.

The occurrence of such undoubted estuarine forms, in a position so far above the regular limestone, makes it doubtful as to what portions of these Upper Shales and Sandstones really are of fresh water origin.

The Upper Shale and Sandstone is best observed near the Spa at Scarborough, where the group may be seen resting on the Limestone-series. A stroll at the base of the cliff here affords a good insight into the mode of its deposition. Its thickness underneath Wheatcroft is about 160ft., but at Gristhorpe it has already dwindled to 80 feet, according to the measurements of Dr. Wright.

Lithologically, this formation is remarkable for an immense quantity of hard siliceous rock, which is sometimes bedded, and sometimes concretionary, in enormous doggers, and occasionally puts on the appearance of a quartzose grit. A small dogger full of carbonized fragments is here shown. This sort of rock is very characteristic of the moorland districts, of which it occupies a considerable surface, especially towards the higher parts. Large fragments of it may be seen dotting the heathery expanse, where they seem almost to defy the powers of denudation. These I believe to be the "Crowstones" of Young and Bird, who state that of this material several of the ancient rude monuments have been made. At Scarborough works are established for making pipes, tiles, &c., from the shales of this series.

As regards Molluscan remains, I have already noticed the myaciform shells in the flaggy sandstones at Maybeck. In another little gorge, communicating with the upper Derwent, there is a hard, sandy bed, full of casts of a small *Ostrea:* in this case, too, all lime has been removed.

Again, near White Nab on the coast, and about 20 feet (quoting from memory) above the top bed of the Scarborough Limestone, there is a sandstone bed, which is a perfect mass of shells and casts of shells of a kind of *Unio*, of which I cannot find any notice in the books. Specimens in good condition are not easily procured. A few of the best are exhibited. What appears to be the external ligament is well preserved in some of the specimens, which are also much worn at the umbos.* The shell bed is over-

* Mr. Leckenby has since obtained a cast of the interior of this shell, which shows that the hinge is edentulous. It must, therefore, be referred to *Anodon*.

lain by, and intermingled with, a few inches of an extremely rich ironstone. Another instance, if more were needed, how frequently in these Lower Oolite beds of Yorkshire the decomposition of organic matter has determined the segregation of salts and oxides of iron. The carrying sandrock is much false bedded, and as it dips towards the south the cap is traceable as an ironstone for a considerable distance. Some of the shells lie flat, and others upright; there is also much carbonized wood in the bed.

Another peculiarity of the Upper Shales and Sandstones is the quantity of Scarbroite in the crevices of the rocks, descending also into the upper part of the limestone itself. It is a kind of hydrous silicate of alumina, remarkable for the very small quantity of silica it contains. Vernon found only 10 per cent. I am inclined to think that it differs considerably from *Allophane*. Its presence would seem to be associated in some way with the decomposition of ligneous matter.

4. The Cornbrash.—The highest fossiliferous zone of the Lower Oolites is in some respects the richest of them all, for although only three or four feet thick, the Cornbrash of Cayton and Gristhorpe Bays in some places teems with fossils, and many of these, as also at Scarborough, are in excellent preservation. It would seem as though marine life, which, in this region, had been struggling against adverse circumstances ever since the last days of the Lias, at one time checked by floods of sand, at another time cut off, perhaps, from communication with the sea, had at length obtained fair play. Yet even here there is a remarkable paucity of Cephalopoda. There appears to be only one species of *Ammonite*, viz., *Ammonites Herveyi* (Sow.), the *A. terebratus* of Phillips, and *A. macrocephalus* of Schlotheim. This is tolerably plentiful. The splendid collection obtained from the Cornbrash of the Yorkshire Coast, by Mr. Leckenby, is now in the Cambridge Museum. Many of the shells are well known, through the figures in Dr. Lycett's "Supplement to the Great Oolite Mollusca." A list of Mr. Leckenby's Cornbrash collection is now on the table, and there are also exhibited a few of the most easily procurable fossils, viz.—

List of Fossils Exhibited from the Cornbrash of Scarborough.

*Ammonites Herveyi (Sow.)	Trochus sp.
Chemnitzia vittata (Phill.)	Pleurotomaria granulata (not Sow.)
Littorina punctura (Bean.)	,, sp.
Amberlya armigera (Lyc.)	Acteonina Scarburgensis (Lyc.)

results, therefore, that those reaches of the valley which follow its main direction will exhibit the beds of the various formations in the order of their succession, where no dislocation or surface accumulation tends to mislead or obscure.

Such is that portion of the valley N.E. of Castle Howard Station for about a mile in the direction of Hutton Banks. The section is supposed to run a little to the westward of the valley, but roughly parallel to it until the river begins to curve round to the S.E., when the line of section gradually leaves it for the nearest part of the Calcareous Grit escarpment in Hutton Banks.

The total distance is 2000 yards. From the edge of the Mount Pleasant quarry to Crambeck the direction is N.E.; from Crambeck to Hutton Banks edge E.N.E. As the line of section is some little distance from the railway and the river, the position of the beds is not exactly the same as would appear to anyone walking along the line; for the beds roll a little towards the river, and are, therefore, all lower in the bank side than in the position exhibited in the line of section. It crosses the Beck about 200 yards above its junction with the river.

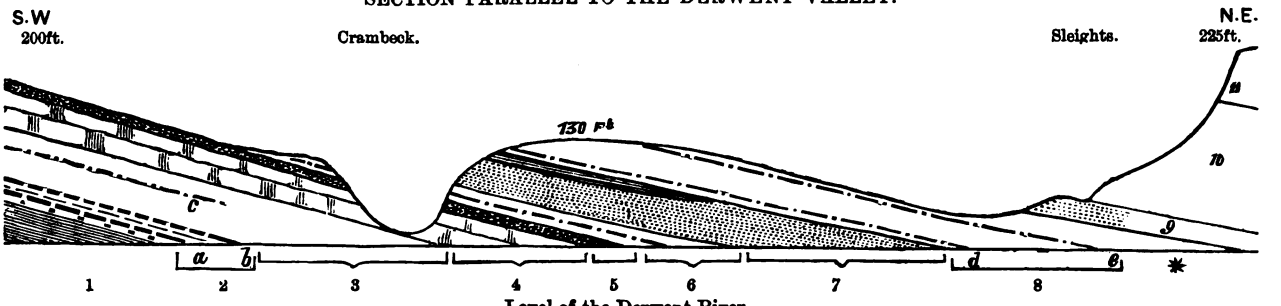
In this moderate traverse of little over a mile we meet with the whole of the Lower Oolites of this immediate locality. The outer portion of the Howardian Hills consists, as has been stated, of Lias, and into this Lias the Derwent Valley cuts deeply. The Castle Howard Station is on the Supra-Liassic Shales, but a very few yards North of Castle Howard Station the railway shaves off a little corner of the bank, where may be seen a ledge of ferruginous rock resting on two or three feet of a peculiar grey sandstone. This is possibly the "Top seam" of the district. It partly represents the Lingula-bed of the coast, and is most likely about the base of the Blue Wyke series. We may thus accept it as the datum line whence to estimate the Oolites of the Derwent Valley.

In the annexed figure, page 323, the sequence from No. 2 (*a*) to No. 8 (*e*) may be considered pretty accurate. Between this latter and No. 10 the sequence is doubtful, and will require further investigation.

The beds are represented as having a north-easterly dip, and this is arrived at from a consideration of the general strike rather than from local observations of dip, as these are very variable. The hard beds, for instance, frequently roll over towards the valleys, owing to the undermining and removal of the shales and looser sands. The amount of dip is usually from 2 to 4 degrees.

Fig. 7.

SECTION PARALLEL TO THE DERWENT VALLEY.



Length of Section, 2,000 yards. * Datum line 50ft. above Sea-level.

* The level of the Derwent is almost exactly 50ft. above Ordnance Datum, between Castle Howard and Hutton Stations. It may be necessary to explain that the beds are never actually traced down to this line, nor is it at all certain that they would maintain such a uniform thickness, supposing they could be actually observed in the position there assigned to them. The Lower Oolites of Yorkshire are far too irregular in their development for any one to feel sure of the thickness of a bed the moment it is out of sight. Hence the measurements must only be deemed to hold good for the places where actually taken. The observation that beds often diminish in the direction of their dip may be true here as elsewhere. 1 and 2 are best observed from the railway north of Castle Howard Station; 3 occupies the middle of the slope; 4 may be well studied in Mount Pleasant Quarry, the edge of which is at the point marked 200ft. in the section; 5 and 6 are best seen in the Crambeck ravine; 7 and 8 in Stonecliff Wood, overhanging the railway.† Cultivated ground, no exposure. 9, the possible equivalent of the Kelloway Rock, in the Sleights at the foot of Hutton Banks (see sheet 141 of the 6in. map, Ordnance Survey); 10, Oxford Clay of Hutton Banks; 11, Lower Calcareous Grit, forming the summit of the plateau, which, a little further on, attains 250ft. or more.

† It is extremely doubtful what the loose white sand No. 9 really represents. It is found on the surface as indicated in the section, but there is no proof that it actually passes under No. 10. It is just as likely to constitute the upper portion of the great sandy series of the Lower Oolites.

Subjoined are the measurements in explanation of the Section (Fig. 7) in ascending order:—

No. on Section.	Name of Bed.	Thickness. ft.	in.	Where Measured.
1.	Supra Liassic Shales.	0	0	
2.	"Top band" or *Lingula* bed(*a*) 5 0 Blue Shale ... ... 8 0 Hydraulic Limestone (*b*) ... 3 4	16	4	Mount Pleasant Shaft.
3.	Beds between the Hydraulic Limestone, and the Main Limestone, including a band of Ironstone (*c*).	38	0	Ditto.
4.	Main Limestone.	28	0	Mount Pleasant Quarry.
5.	Loam and Sand (potters' earth).	8	0	Crambeck Escarpment.
6.	Upper Limestone.	11	0	Ditto.
7.	Middle Sands...	30	0	Crambeck Escarpment and Stonecliff Wood.
8.	Stonecliff Wood Series, consisting of a hard fossiliferous bed (*d*) at base, 18 to 20ft. of Sands, and about 7ft. of fossiliferous beds at top (*e*).	30	0	Stonecliff Wood.
	Total	161	4	

Following the grouping adopted in the section (Fig. 7) we have:—

1.—The Supra Liassic Shales, which may represent the Striatulus-beds.

2.—The "Top seam" (*a* of the section) is perhaps the one which was worked as an ironstone, but the driftings on the west side of the valley have been discontinued for some time. It does not appear to be very rich or profitable, in spite of the unusual facilities of carriage. If the seam, which was worked, is the same as the Lingula ironstone close to the station, it is not exactly in the position of the "Top seam" of Rosedale and Grosmont, which belong to the Dogger, but is lower down. The conjunction of *Lingula Beanii* with *Discina reflexa*, observed in a specimen from here, seems conclusive as to its being about the base of the Blue Wyke Sands. Dr. Wright pointed out its relation to the Blue Wyke Sands in 1859. There are several other fossils; *Myacites*, *Avicula*, and *Cardium*, for instance; but their condition is not favourable to a determination of the species. The succeeding shales, not being very accessible are but little known, except through the trial shaft; the remains of fish are said to have been found in them.

The remaining bed of group 2 is the Hydraulic Limestone (*b* of the Section), which has a thickness of 3ft. 4in. at the trial shaft. This is an argillaceous lime and ironstone; it seems to be tolerably persistent over a considerable tract of country at its outcrop. Economically it is rather a failure, except for road metal, in this immediate district, but it has been burnt for lime in the westward, especially about Dalby. The fossils are small and badly preserved. A species of *Glyphœa*, similar to one found to the Blue Wyke Sands, was noted; also a small *Modiola*, like the *M. gregaria* of Quensted. There is also a small echinoderm, most probably a *Pseudodiadema*. Besides these, a very small specimen of *Pecten lens ? Cardium striatulum*, *Pholadomya* sp. *? Gervillia tortuosa* (Phill.), and one or two other fossils were found. These beds may, perhaps, all be referred to the horizon of the Blue Wyke Sands; they measure 16ft. 4in. at the trial shaft.

3. In this group are included all the beds between the Hydraulic Limestone, and the Main or Whitwell Limestone, 38ft. in all as measured at the trial shaft. In the bank side above the station there is no outcrop, and therefore we must again apply to the trial shaft for a knowledge of their composition. *

The lowest of these is a bed of hard black shale, 13ft. thick.

The remaining 25ft. are probably all there is to represent the Dogger and Lower Shale and Sandstone of the coast formation, together 315ft. thick in Peak Cliffs, exclusive of the underlying sands This is an attenuation amounting to twelve-thirteenths of the entire bulk in a distance from north-east to south-west of 24 miles. In sinking the shaft, some of these beds were found to be so loose, that, on breaking through the harder stone atop, the crowbar would drop at once several feet, owing to its not meeting with sufficient resistance. When the lateral support of such loose sands is withdrawn, they slip away, and the hard beds become inclined at a considerable angle. This may serve to explain the puzzling position in which some of the hard beds are found in the Howardian Hills, where sudden reversal of dip is not at all uncommon. A bed of nodular ironstone (*c* of the section) is noted as occurring in the position there assigned to it.

4. We now come to the most important formation of this section, perhaps the nearest approach in North Yorkshire to the typical

* Compare Wright, in Quart. Journ. Geol. Soc., vol. xvi., p. 33.

Inferior Oolites of the Midland and West Midland counties. This is known as the Whitwell or Crambeck Limestone.

By its outcrop in Whitwell parish, it formed an angular escarpment overlooking the Derwent Valley, and thus afforded an excellent site for a Roman encampment. But it has been quarried for such a length of time that these fine natural features are now much modified. This Limestone contains a considerable series of marine fossils, some of which, such as *Pygaster semisulcatus* and *Stomechinus germinans* are quite indicative of its position, as was long ago pointed out by Dr. Wright. In the cabinets of Mr. Reed, of York, and Mr. Strickland, of Hildenley, these are well exhibited. Dr. Wright has published a list of them, Quart. Journ. Geol. Soc., Vol. xvi. pp. 32 and 33. He is disposed to correlate them with those from the Millepore-bed on the coast. In the lists as there published, only six species were found to be identical, but the number common to the two has since been increased. The shells most strikingly common to each are *Modiola imbricata*, and *Ceromya Bajociana*, both very abundant. It may be said that species so frequent in the Lower Oolites do not prove much. *Pygaster semisulcatus* is, however, found in the upper part of the Millepore-bed at Cloughton, and in the same bed occurs a remarkable group of small *Trigonias*, viz., *T. conjungens* (Lyc.), *T. recticosta* (Lyc.), and *T. tenuicosta?* (Lyc.), all of which are in Mr. Reed's cabinet from Whitwell or the vicinity.

As far as external appearance goes, there is a marked difference between this Oolitic Limestone and the peculiar rock of Sycarham, near Cloughton Wyke, from which the majority of the Millepore-bed fossils are extracted. We have seen that this latter is an Oolitic marl, converted into an ironstone; therefore, the great difference lies in the substitution, rather than in the original composition. Not but what the original physical conditions were very different at the time that the Sycarham and Whitwell beds were being deposited. It must also be borne in mind that the area now under consideration was not liable to the enormous irruptions of sand and clay, which so largely prevailed some twenty miles or more towards the north-east during this period of the Lower Oolitic epoch. In this respect, as also in general character, the Whitwell Limestone has somewhat more resemblance to the lowest of the two Limestone series observed south of Scarborough, which is, in fact, the original and typical Millepore-bed.

There is a considerable variation in the thickness of the lime-

stone in Mount Pleasant Quarry, and a very great amount of what appears to be false bedding. The maximum thickness is 28 feet towards the lower end, the general thickness perhaps 20. The lowest beds are usually blue-hearted, and used principally for road stone. More regularly bedded Oolites succeed. These are somewhat iron-stained, and this feature may generally serve to distinguish them from the much whiter Coralline Oolite. To show how variable are the underlying beds, the limestones in this quarry rest at the west end on coarse sandstone, in the middle on shales which cause them to be full of water, and at the east end on a sandstone again. All this tallies with the false bedding before noticed in the lower part of the limestone.

I have not had time to trace the outcrop of this limestone towards the west, but towards the east, on the opposite side of the Derwent, it is well seen at Westow, and then again at Burythorpe, close to the church (where it is nearly 300 feet above the sea), and finally at a farm called Hermitage, not very far from the Wold escarpment.

A few of the fossils are exhibited on the table in a roughish state, and mostly as casts. The shells are a good size of their kind, and give evidence of favourable conditions. Besides those already mentioned, there occur rather plentifully a fine *Pecten*, probably *P. aratus* (Waagen), *Hinnites velatus* (Goldf.), *Cardium Buckmani* (M. & L.), *Cypricardia Bathonica* (d'Orb), *Isocardia cordata* (Buck.), and *Terebratula maxillata* or *submaxillata* (Sow.). Mr. Reed thinks that about 35 species are known from this limestone, but as collectors appear to have made no distinction between the Whitwell Oolite or Main Limestone (No. 4), and the more Sandy Upper Limestones (No. 6), it is not easy to say how many are really known.

5. Rather more than a foot of hard siliceous limestone occurs at the top of the last-mentioned Oolite, and then about eight or nine feet in their fullest development of extremely fine sands and loam. I do not hear of any fossils occurring here, but if any are found they would most likely be the same as those in the sandy beds of No. 6. Amongst these sands are beds of very fine potters' earth, much used by the Romans. Quantities of the old ware are found buried here. In making excavations for the Reformatory, portions of the old kilns were discovered.

6. Above this we find about 11 feet of thin bluish limestones

embedded in reddish sands. Carbonaceous matter in small fragments occurs abundantly in these beds, which are best studied in the ravine of the Crambeck, where they have been quarried for road material. These sands and limestones contain a fair assemblage of fossils, amongst which are *Terebratula globata** (Sow.), *Rhynchonella spinosa* (Schlot.), var. *paucicostata* (Corby), *Lima bellula* (M. & L.), *Lima duplicata* (Sow.), *Pecten personatus* (Goldf.), locality doubtful, *Pholadomya Sœmanni* (M. & L.), and numerous casts of *Greslya*, *Ceromya*, &c., from the interbedded sands, too imperfect to be determined. Part of a cast of the outer whorl of a large discoidal ammonite was also discovered, which must have belonged to an individual of immense size. There is a similar one in the York Museum, marked "Great Oolite, Brandsby." If we may judge by casts, the large *Pecten* of the Main Limestone occurs here also.

The presence of *Rhynchonella spinosa* might lead to the idea that these beds were high up in the Inferior Oolite, almost on a level with the Trigonia-grits of Cheltenham perhaps. But apart from the difficulty of correlating such distant areas, where, as in the case of the Upper Limestones of Crambeck, the physical conditions are so different, there is scarcely sufficient evidence amongst the other fossils to justify such a supposition, though I admit that in the first instance I was inclined to place them on that horizon. As regards their Yorkshire equivalents, in the more westerly part of the Howardian Hills they are probably represented by a portion of the slaty limestones of Brandsby; whilst on the coast some of the upper beds of the great Millepore series at Gristhorpe may be near them.

7. The Middle Red Sands which succeed may be viewed as a continuation of the last beds. They appear, as measured to the base of the Stonecliff Wood series on the edge of the Crambeck ravine, from 20 to 25 feet thick, but vary much, especially towards the Derwent Valley, where they seem to increase at the expense of the limestones (No. 6 of the section Fig. 7). In these sands the fauna of the underlying beds appears to be dying out,† and we get

* Some collectors call this form *T. globata*. It certainly is globose, but more like small round specimens of *T. submaxillata*.

† The dying out of a fauna in its application to the Lower Oolites of Yorkshire often means that when conditions unfavourable to life set in over any given area the Mollusca, &c., die, or become stunted, or cease to be prolific in that particular area. They may be abundant at no great distance, and when the conditions are again suitable they come in again with a few alterations as to species, perhaps

nothing but *Ostrea* and *Avicula*, with occasionally an attenuated specimen of what seems to be *Modiola imbricata*, struggling, as it were, against adverse circumstances, and presenting a strange contrast to the really fine shells from the Lower Limestone beds (No. 4 of Section).

The next step in ascending order is rather a puzzle. On the steep banks of Stonecliff Wood, overlooking the York and Scarborough railway, which runs in the valley at its base, there occurs, more than half way up, a belt of boggy ground, which seems to intervene between these Middle Sands and the series which occupies the upper 30 feet of the wood. This boggy ground is probably the result of an indefinite thickness of shale, which, as it cannot be traced the whole way along, is viewed as a local intercalation, and classed, provisionally at least, with the sands of No. 7. It may, of course, be due to a certain quantity of argillaceous matter in the sands, which are tolerably variable, and contain hard beds with small obscure fossils in various places.

8. Reposing on these last, and forming a sort of escarpment, facing the Derwent Valley along the top of the wood, is the group which I have ventured to call the Stonecliff Wood Series. It consists of foxy sands, held up and hardened, especially towards the base and the upper part, by intercalated beds and lenticular masses (potlids) of arenaceous or siliceous limestone. The base of the series (*d* of the section) is a bed two or three feet thick, more or less in places, of an extremely hard, rather fine grained siliceous limestone, with a tendency to lamination, which causes it to break up, though with difficulty, into flaggy pieces. This contains a great number of small shells; a small *Ostrea* or *Placunopsis*, and a very small *Astarte* are especially abundant, and there is also the same *Myacites*, which is so characteristic of the upper beds (*e* of the Section); but the shells are so much compressed, and in such bad condition, that even *genera* are not altogether clearly indicated. Fragments of wood and curious vegetable markings are plentiful. This stone has been used for the middle portion of the railway wall underneath Stonecliff Wood. The bed from which it has been taken may be seen close to the railway wall, about 55 yards from

according to the time that has elapsed, and the degree to which the old conditions are restored. Meanwhile the interval is marked over the area in question by beds of sand and shale, which generally have the reputation of being unfossiliferous, but which contain more Invertebrate remains than is usually suspected; though as those are small and badly preserved, they are of little interest to the collector.

the east end of the wood, and may thence be traced rising towards W.S.W., at an angle of two or three degrees all along the side of the slope to the little notch at the end of the terrace, somewhat to the left of the point marked 130 feet in the Section (Fig. 7). This Section, however, as before intimated, does not exhibit the beds quite in the position they present to one viewing them from the railway, owing to the very considerable curve which here obtains.

The bed *d* there forms the base of the escarpment, which becomes merged in the general slope as the Stonecliff Wood Series approaches the railway; so that the two sandy series, *i.e.*, No. 7, and the middle parts of No. 8, might very well be confounded together. This is more especially likely to be the case in the summer time, when the whole surface is such a tangle of brushwood and brakes. Indeed, if it were not for the rabbits, which, by burrowing, display the sandy beds, and also for certain trial holes made formerly to procure stone, it would be almost impossible to ascertain the sequence. The intervening 18 to 20 feet, *i.e.*, the centre portions of No. 8, consist for the most part of loosish, red and white sand, and then we arrive at some seven or eight feet of hard beds, *e.* of the Section, which form the cap of the terrace all along the brow of the wood. These beds may be described generally as consisting of hard tables, and doggers, or "potlids" of grit, chiefly quartzoze, cemented by the carbonates of lime and iron. The oolitic structure is very slightly developed. These are often separated by loose, sandy beds, which are very red from oxidation of the iron, whilst the harder courses retain their pale grey colour, and contain many small carbonaceous fragments. The shells occur mostly as moulds, or impressions, though in the case of some of the Monomyaria considerable portions of the shell or its replacing matter, is still there, but from its splintery nature it is almost impossible to obtain perfect specimens. The shell of a *Gervillia*, under examination, was found to consist of crystalline carbonate of lime, with a moderate proportion of spathic iron, the partial oxidation of which gave a slight brown tinge to the whole.

These beds are a perfect mass of fossils; indeed, as to quantity there is nothing at all approaching it in any formation, of which we have cognizance, within the area under description. The highest bed observed is crammed with small *Aviculæ*; below this is a bed containing very large *Aviculæ*, probably of the same species. Next

is a bed with *Avicula* and *Myacites* mixed, then some loose sand, and then a hard bed full of casts of several species. This arrangement may, however, be quite accidental, and would not, perhaps, hold good all along the line. A circular excavation close by the railway at the end of the wall shows a double tier of these hard beds with red sands between, but all full of shell impressions. The railway wall hard by is the best place for collecting.

The following is a list, submitted with much doubt, on account of the imperfect preservation of the specimens obtained :—

Ostrea flabelloides (Lam.)
Placunopsis sp.
Pecten lens (Sow.)
Avicula Braamburiensis (Sow.), one or two varieties.
Gervillia acuta (Sow.), large and small varieties.
Perna rugosa (Goldf.)
Pinna, immense size.
Mytilus sublœvis (Sow.)
Cucullæa sp.
Trigonia signata (Ag.)
Astarte sp.
Myacites securiformis (Phill.), very plentiful.
Myacites decurtata (Phill)., one specimen.
Pholadomya, like P. angustata (Sow.)
? Terebratula maxillata (Sow.)

With this series the Lower Oolites of the Derwent Valley terminate, as far as any actual observations can be made. It will be seen, however, on referring to the section, that there is a blank space marked * before reaching bed No. 9, which latter occupies a doubtful position. Above this commences No. 10, most undoubtedly Oxford Clay. It is not at all improbable that the vacant space (* of the Section, Fig. 7) might be compressed still more, so that the loose sands of No. 9 would rest directly upon the hard beds, just described. On the other hand, the unexplored space might conceal a fault, which would, of course, upset all calculations as to the thickness of the Lower Oolites in this region. A tolerably deep trench, or a boring for a few yards at the outcrop of No. 9 would easily solve the difficulty. On the supposition that there is no fault, the total thickness of the Lower Oolites from the Supra Liassic Shales of Castle Howard Station to the top of the Stonecliff Series, being, as we have said, about 160ft., if we throw in the whole of the remainder to the base of the undoubted Oxford Clay, it would not raise the thickness to 200ft.

Then comes the very important question: what do the fossiliferous beds of No. 8, and especially those marked *e*, represent on

comparison with the coast section? With which of the four fossiliferous zones of the Lower Oolites should they be correlated?

This is a subject which has caused much discussion and speculation; one very experienced collector would place them even as high as a portion of the Kelloway Rock; other persons, myself amongst the number, have at times referred them to the Cornbrash; but a more extended acquaintance with the fossils, supposing the determination of the annexed list to be at all accurate, seems to point to the upper portion of the "Scarborough Limestone" (Grey Limestone of Wright, Bath Oolite of Phillips) as being the nearest in respect of organic remains to the top beds of the "Stonecliff Wood Series." The immense quantities of *Avicula Braamburiensis* and *Gervillia acuta* are in favour of this supposition. The presence of *Perna rugosa*, *Mytilus sublævis*, and the enormous *Pinna* still further remind one of the Grey Limestones; and if the very fine *Trigonia* is correctly determined to be the *T. signata* of Agassiz, the case may be almost deemed established.

If so, there seems to be but little room for the Upper Shale and Sandstone, Cornbrash, and Kelloway Rock, between this and the Oxford Clay. Omitting the blank space (*) as a sort of *terra incognita*, No. 9 represents a considerable ridge of loose white sand at the base of Hutton Banks. This occupies a position where we should expect to find the Kelloway Rock, but beyond this there is no evidence in the line of section of what it really represents. Nearly a mile higher up the Derwent Valley, and in an almost similar position with respect to Hutton Banks, there is seen 5ft. of irony calciferous sandrock, making a sort of terrace at the base of the hill. A fragment of this was found to contain *Rhynchonella varians*, and a portion of a broad *Gryphæa*, such as is met with in the upper part of the Kelloway Rock at Scarborough. There seems no reason to doubt that this rock, here alluded to, does form the base of the Oxfordian or Middle Oolites at that particular spot. It may, however, be yet open to question whether or not the unfossiliferous arenaceous beds, forming the lower mass of the so-called Kelloway Rock in Yorkshire, should not be deemed a part of the great sedimentary series, which we have been endeavouring to trace.

If we look back for a moment at the ground traversed in the Section, we find that about the close of the formation of the Whitwell Oolite, No. 4, there set in a period when arenaceous deposits assumed the ascendancy, to the exclusion in a great measure of

argillaceous ones in this particular area; but that there was a considerable assemblage of Invertebrate forms of life, indicating marine and partly also estuarine conditions during portions of this period, as shown especially in the arenaceous limestones of Nos. 6 and 8. Moreover, that however much the fauna of these beds seems to differ, as far as we are enabled to study it, there is considerable uniformity of physical conditions evinced by the recurrence of sandy limestones and loose sands over and over again to the base of the Oxford Clay itself. On the coast the corresponding beds, besides being much thicker, exhibit more variety. It seems probable that in the north-western portion of the Howardian range this arenaceous series assumes much larger proportions.

Reverting once more to Hutton Banks, we observe that the escarpment is capped by Lower Calcareous Grit. Therefore, if we except the top beds of that formation, and also the Coralline Oolite, we have in a length of 2000 yards the whole of the Lower and Middle Oolites displayed in one section. A similar one in the Moorland Chain from the top of the Lias in Goathland to the Lower Calcareous Grit escarpment overlooking Newtondale would have a length of five and a-half miles.

Here, then, at the base of the Middle Oolites, we must for the present pause, having only accomplished half the journey which we originally contemplated.

NOTE.—There seems to be considerable obscurity as to the real junction between the Lower and Middle Oolities in the Howardian Hills generally; and this partly arises from the uncertain nature of the sandy beds which prevail about this horizon. But the difficulty is increased by the varying and uncertain position of solid and well recognised beds, which can hardly be explained otherwise than by the faulting or shifting of the strata. For instance, the Whitewell Oolite, No. 4 of the Section, the top of which, in the Crambeck ravine, is not more than 80ft. above sea level, with an apparent dip to the E. N.E., is found, less than half-a-mile due north of the quarry, at a height of 225ft., being exactly on a level with the Lower Calcareous Grit escarpment of Hutton Banks, in the direction of which it seems, in the line of section, to be dipping. Nothing short of a detailed and accurate survey, such as is now being undertaken by the Government officers, can explain such facts. That these apparent dislocations are due to the sliding away of large masses, bodily in the direction of the valley, is not improbable.

SUMMARY

OF THE

PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION

DURING THE YEAR 1873.

January 3rd—ORDINARY MEETING.
Paper read—"On the Cambrian and Silurian Rocks of Ramsey Island, St. David's;" by HENRY HICKS, Esq., F.G.S., &c.

February 7th—ANNUAL GENERAL MEETING.
Annual Report for 1872. Election of Officers.

" 7th—ORDINARY MEETING.
Paper read—"On the Diprionidæ of the Moffat Shale;" by CHARLES LAPWORTH, Esq., F.G.S.

March 7th—ORDINARY MEETING.
Paper read—"On the Geology of Brighton," Part I.; by JAMES HOWELL, Esq.

" 27th—VISIT TO THE BOTANICAL DEPARTMENT OF THE BRITISH MUSEUM.

April 3rd—VISIT TO THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

" 4th—ORDINARY MEETING.
Papers read—1. "On the Origin and Present Position of the Diamonds of South Africa;" by G. C. COOPER, Esq.
2. "On Some Fossils from the Margate Chalk;" by JOHN WILLIAM WETHERELL, Esq.

" 14th and 15th—EXCURSION TO BANBURY.

" 21st—VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY.

" 26th—EXCURSION TO CHARLTON.

May 2nd—ORDINARY MEETING.
Paper read—"On the Valley of the Vézère, Perigord, its Limestones, Caves, and Pre-Historic Remains," by Professor T. RUPERT JONES, F.R.S., &c.

" 5th—EXCURSION TO AYLESBURY.

" 23rd and 24th—EXCURSION TO EASTBOURNE AND ST. LEONARDS.

" 31st—EXCURSION TO FINCHLEY.

June 6th—ORDINARY MEETING.
Paper read—"On Ammonite Zones in the Isle of Thanet;" by FRANCIS ALFRED BEDWELL, Esq., M.A., &c.

" 11th—EXCURSION TO BRIGHTON.

" 28th—EXCURSION TO HATFIELD.

July 4th—ORDINARY MEETING.
Papers read—1. "Sketch of the Geology of Northamptonshire;" by SAMUEL SHARP, Esq., F.S.A., F.G.S., &c.
2. "An account of the Eruption of Mount Vesuvius, of April, 1872;" by J. M. BLACK, Esq.
3. "On some New Crag Fossils;" by ALFRED BELL, Esq.

" 5th—EXCURSION TO PLUMSTEAD AND CROSSNESS.

" 21st, 22nd, 23rd, 24th, 25th, and 26th—EXCURSION TO MALVERN.

November 7th—ORDINARY MEETING.
"Opening Address of the Session, 1873-4;" by the President, HENRY WOODWARD, Esq., F.R.S., &c.

December 5th—ORDINARY MEETING.
Paper read—"The Yorkshire Oolites," Part I.; by WILFRID H. HUDLESTON, Esq., M.A., F.G.S., &c.

ORDINARY MEETING, JANUARY 2ND, 1874.

HENRY WOODWARD, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Geological Essays," by Chas. Rickets, M.D., F.G.S.; from the Author.

"Geological Sketch of the Province of Cadiz," by J. McPherson; from the President.

"New South Wales—the Oldest and Richest of the Australian Colonies," by Charles Robinson, Esq.; from Professor Tennant, F.G.S., &c.

"Handbook for Emigrants to Queensland, Australia;" from Professor Tennant, F.G.S., &c.

"Glacial Drifts of Muswell Hill and Finchley," by Henry Walker, F.G.S.; from the Author.

"Mining and Mineral Statistics."

"Abstracts of Proceedings of the Geological Society of London;" from that Society.

"Journal of the Quekett Microscopical Club," No. 24; from that Club.

"Transactions of the Manchester Geological Society," Vol. xiii., part 1; from that Society.

"Abstracts of Proceedings of the Liverpool Geological Society," 1872-3; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. viii., No. 4; from that Institute.

"Journal of the London Institution;" from that Institution.

The following were elected Members of the Association :—

William Richard Brodie, Esq.; John Gunn, Esq., M.A., F.G.S.; Samuel Harraden, Esq., F.G.S.; Charles Ingall, Esq.; Frederick William Rudler, Esq., F.G.S., M.A.I., &c.

Francis Alfred Bedwell, Esq., M.A., &c., and F. G. Hilton Price, Esq., F.G.S., &c., were elected Auditors of the Accounts of the Association for the year 1873.

The following Paper was read :—

ON THE NATURE AND FORMATION OF FLINT AND ALLIED BODIES.
By M. HAWKINS JOHNSON, Esq., F.G.S.

On the Origin and Present Position of the Diamonds of South Africa.

By G. C. Cooper, Esq., of Graaf Reinet.

(*Read April 4th*, 1873.)

This communication has been prepared as a statement of reasons for dissenting from the theory of an igneous action upon the spot at which the diamonds are now found as being the explanation of their origin and present position, my observations tending to induce me to form an opposite opinion.*

There are considerable differences between the topographical features of the country in the neighbourhood of the Diamond Fields and those of the country between there and the coast. At the same time I believe the difference is more one of degree than of kind, the agents giving the features to the landscape being the same in both cases. In the vicinity of Graaf Reinet the mountains consist of grey and blue clay rocks. The "Karoo flats," though called "flats," have many minor ridges and undulations over their surface. The grey rocks are often of mountain elevation, and capped by greenstone as if poured out under water. On the journey to the "Fields" I frequently observed pinnacles of these rocks left, showing more or less of the former height of the present surface, the denudation seeming to be due to atmospheric and aqueous agency, and the long curved lines of the sides of the elevations pointing, in my opinion, to a lengthened period of water action. The loss of surface is traceable over the whole surface of the colony, the main difference in appearance at the Diamond Fields being long undulations between low ridges. At the same time the trap dykes come to the surface all over the locality in these undulations, and forming the outside ridges (*Randt*), as shewn in Fig. 1.

Fig. 1.

* See paper "On a visit to the Diamond Fields of South Africa, with notices of Geological Phenomena by the Wayside," by John Paterson, M.A., Proc. Geol. *Assoc.*, vol. iii., page 70.

These intruding dykes are of more than one kind, but still the same as those in other parts of the Colony. I am inclined to infer that these dykes never broke through the surface at *a*, *b*, *c*, while at *d* such may have been the case, the wearing away of the surface giving a "sacked" or sunken appearance (Proc. Geol. Assoc., Vol. iii., p. 72). This "sacked" appearance seems to me to be not an inclination to the dykes, but of the opposite character. The rocks having been removed, the dyke *d* was left, and the summits of *a*, *b*, and *c* exposed.

The "stuff," in diggers' parlance, is described as "a kind of marl, or mixture of lime and clay—whitish by the presence of lime in it when first dug out, but soon under exposure changing into a greenish tinge, approaching that of olivine in some trap rocks" (ibid, p. 73). This description scarcely accords with the result of my observation, as all the "stuff" I have seen was greenish while moist and *in sitû*, becoming white upon drying. The amorphous condition of the "marl-stuff" is, in my opinion, one of the proofs of the aqueous deposition of the diamantiferous soil, and the occurrence of so great an abundance of fragments of the clay rocks interspersed throughout the whole mass should raise the question of the manner of the formation of the mixture and of the origin of the materials composing it.

I have not seen Jagers Fontein, which is described as being "surrounded on every side by a ridge of trap rising to some considerable height above the surrounding country," but unless the dykes rise up at a distance of some three or four miles, leaving the sunken and undulating surfaces, this description is scarcely that of the features of other localities.

If by "the nodules of marl" I may understand a material identical with the "stuff" of the diggers—and from the fact of crystals and siliceous nodules being sifted from this stuff, it shews a mixed deposit—we have another proof that the deposit was not in its original position. These observations of Mr. Paterson's, while made at Jagers Fontein, are described by him as being the same at the other diggings. The "effloresced tufa," or "limestone," however much in local appearance it may seem to have "boiled up from beneath" (ibid, p. 75), will not bear out such a supposition when looked at as the almost universal covering of the rocks, and mingled with the soil of the Colony.

The red sand covering the Flats, so well described by Mr. Pater-

son, when washed hardly discolours the water; and a siliceous red sand falls down, which under the microscope is a very beautiful object. A walk across to the dyke-ridge or Kopje will shew that the dyke does not give this sand, but a dull, earthy looking, opaque sand, overlying at their junction the red sand of the flat, which being semi-transparent, is distinctly different. The red sand of the Flats varies in depth from a few inches to four or five feet.

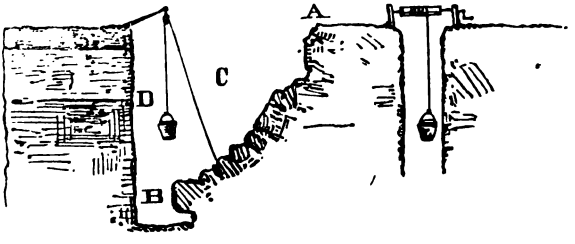
We now come to the New Rush diggings, which I can scarcely describe as an "oval space, enclosed around by the trap dyke." True the dykes make their appearance in all these diggings; but how? Not as enclosing what is now being made into a great pit, but as forming only exceptional portions of the walls of the cavities; New Rush, De Beer's and Du Toits', having similar geological characters. The "floating reef" of the diggers being a stratum less removed by decomposing influences than the one under it. The "stuff," of course, being under it, and filling up the cavity thus formed. The faces and joints of these cliffs have the rounded form given by exposure.

I will now allude to other appearances indicative of the action of water.

But, first, it may be as well to ask what is the real character of these cavities. The New Rush, which is worked the most systematically, shews a cavity, as if the floor had sunk down, or was produced by some convulsion separating the sides, giving the sections of the dykes referred to.

Then the mode in which these cavities are filled by the materials shews a carrying and packing of them very decidedly. I will give a section of one of the claims in which I was working—

Fig. 2.



In this diagram I shew first a slope (A, B) of fragments of clay rock, concreted together with the lime, the angular space C having been worked out leaving the stones in their places. At

B is a large stone, as it were forming a footing to the incline. From the point D upwards is a mixed deposit of lime and claystone fragments; below this is the "stuff," as it is called. The stone B rested, or was bedded, in a layer of the "red sand," or "burnt brick" of the diggers. This layer extended over the floor of the claim, and was four to six inches thick. As I worked this out, I gradually undermined the stone B, removing all the "burnt brick," and coming again to the "stuff." Now this "burnt brick" is the red sand that covers the surface of all this part of the country. It may be traced coming from the surface in inclined lines, like the stones A, B, in bands two or three inches thick. The colour in these bands is brought out by being mixed with the lime overflowing the general surface. These lines and layers of the surface sands would, I think, indicate changes in the currents bringing the materials filling the cavities, because they occur at various depths in the stuff.

In addition to the slope A B, there had been a great deal of claystone fragments poured into the adjoining spot, but not so regularly packed as A B. Such quantities of stones being found in isolated spots render some of the claims much less profitable than others. Besides these packed stones, large pieces of the clay rock frequently occur, often singly and of large size, being entirely isolated from any such deposit as A B, and altogether surrounded by the "stuff." All such fragments placed in this manner, and they are innumerable throughout the diggings, go a long way towards pointing to a carrying power having brought them into their present positions. I may also mention that the shaft sunk is only a few feet from the edge of the incline A B, and "stuff" was being brought up; consequently the amount of stone was not very great. This claim was near the centre of the New Rush diggings.

I have used the term "carrying power" as being more comprehensive and inclusive than "water-power." I do not feel satisfied with this term alone. Some of the appearances, such for instance as the preservation of the angularity of the fragments of claystones, appear to me to indicate another sort of transport, such as *ice* would furnish. There has been rolling power also, as shewn by the rounded pieces, not but that the two kinds may have been put into their present positions by ice, after the one had suffered the rolling process. The alternations may have been produced by rushes of water from different points, but bringing their *débris*

into the general current which was filling these cavities; and would not glacial action have the same result?

It is to be noted that, at a very short distance from a well, through the "true carboniferous shale" of Mr. Paterson, another might be seen sunk through shales of an ochreous tint and other shades of colour, and rock. True, diamonds are not there found, but I ascertained that at the depth where these "carboniferous shales" commenced in the well-pit, namely, from five to seven feet below the surface, the *true marls* within the reef also commenced at exactly the same depths, and for the first time did the diggers look for any number of diamonds in their claims. We are not told what this upper crust of five to seven feet consisted of. In the claims it was a sort of concrete of lime and "shales," clay rocks, as I have termed them. Moreover, it is not stated that the diggers do not find diamonds in this five to seven feet of surface material, but that "they do look, but not for any number of diamonds."

How comes it that there are any diamonds at all? This concrete is searched, and I was told diamonds were found in it, but not in any number; and if found at all, it might account for the diamonds upon the surface over a larger area than the diggings. Now the two facts—of diamonds being in the "marl," of Mr. Paterson; or "stuff" of the diggers, as well as in the upper five to seven feet of concrete—is not very satisfactorily made out, or accounted for, if this "marl" "stuff" be *in situ* as concerns its formation. The whole would be accounted for by supposing the "stuff" to have been thrown in by water until the pit was nearly filled, and then the filling completed by lime and stone, with also a few diamonds. Moreover, as I must again repeat, the mixed character of the "stuff," as containing fragments of the same rocks as are included in the five to seven feet of the surface, would point out that streams bringing material from different sources, though they may have been neighbours, had given the supply of "stuff" now being excavated.

Not having seen the Pniel diggings, I cannot speak of these except from Mr. Paterson's paper; and here he refers to the diggers working in a bed of the "well-known marl," with round greenstone boulders. Rounded, but not of necessity from rolling, as these dykes in their cleavage give angular blocks, partaking of the cleavage of the rocks surrounding them, their angles gradually

wear away in such a manner that ultimately round boulder-like blocks are produced, appearing in some cases at first sight as if the surface was strewn with cannon balls. They may be traced as passing from a recent angular fracture or cleavage, into all the grades up to the round form.

I will now attempt some few remarks upon the general view of the subject. First, as to diamond-beds being alluvial deposits, as far as they have been known hitherto, and as to whether the South African diamond country differs from others; is it, in fact, an exception to the rule. In the South African Museum at Cape Town there are pebbles (agates and others) from the Brazilian diamond soils similar to those found at Klip Drift, &c., shewing a similarity, at least in some respects, of associated *débris*. In both localities these pebbles are rounded by much wear, as on a beach. There seems to be the same agates and the same vitrified clays; and all shewing the influence of the same long wear and tear of water, and in both cases associated with diamonds.

Not having personal knowledge of Klip Drift, I will pass on to that of the "stuff" of the New Rush, &c. This is called "limey stuff," as though lime were its main constituent. There is one point I think deserves notice or remark. Would it be possible for the diggers to work in *lime stuff* with the same impunity as they do in this material? It is, or was, no uncommon thing, in the absence or scarceness of water supply, for the diggers to hang out their apparel, shirts, &c., in the sun, and again wear them without their being washed. If lime were present, could this have been done with any comfort to the skin? This "stuff," in place of being harsh and dry to the touch, has a smooth soapy feel; it does not seem to soil or dry the skin like lime. It has more the feel of serpentine, or those rocks containing magnesia, and is doubtless steatitic.

I see it reported that a magnesian formation has been met with in Russia, in which small, but true diamonds have been found. If this be the case, it may be that the "stuff" taken out of the South African diamond mines may have a similar origin. At the same time, as regards its present position, it is an alluvial deposit, brought, possibly, from a great distance, having in its transit become commingled with the *débris* of other formations, as it contains, in addition to fragments of clay rocks, pieces of several other rocks, crystals, pieces of garnet, which are fragments of larger pieces that are found somewhere about the Vaal River.

These smaller fragments of garnet I have found more or less water worn, and brought up from all depths.

At De Beer's I found a rounded piece of garnet, about ½ inch diameter, rough from the wear of rolling. There are quartz and other crystals, mostly shewing that they have been subjected to friction or violence. Mixed up with this "stuff" there is a large quantity of small flakes of mica, small green crystalline fragments (possibly the "emeralds" of the diggers), but the whole so mixed together in a manner not in accordance with the appearance of an original formation. Most of the crystals are in a broken condition, an indication that they are not in the situation in which they were formed.

I have before me pieces of rounded lumps of two crystalline rocks, probably trap. These lumps evidently have been subjected to much wear from rolling, and decomposition of the surface. The disintegrated particles of these rocks go to make up the mass of the diamond-bearing "stuff." The microsc shews both sets of particles therein. I have seen these kinds of pebbles above the mass of "stuff" included in the lime concrete of the first five to seven feet, which lies above the diamond stuff, and beneath the red sand of the surface. One of these rocks yields the mica, which is very abundant, the other the small green crystalline particles, in addition to their other portions. It would seem that in the course of the disturbance to which the surface of the Colony has been subjected, in the locality of the Diamond Fields. large cavities or fissures had been made, which, after remaining open for a period, had been submerged, and filled with their present diamantiferous contents. Somewhere in the vicinity of the Fields there are deposits containing, it is said, corundum, torquoise, garnet, and other stones of the kind. Samples of these have been taken to England to try the market.

I have recently received a piece of what is termed "chalk" by the diggers, which, from microscopic observations, I would infer to be in all essential points the same as the tufa that is so abundant, with this exception, that this has been broken up, disintegrated, as on a beach, and thus made into a softer form, after its deposition as tufa. It gives the same white streak as ordinary chalk. It has imbedded in its surface some sands, granules, and black crystals, resembling, and, as I think, the same as occurs in a sample of stuff lately given to me, from *80 feet depth*. Its component particles are crystalline and trans-

lucent, and from $\frac{1}{2000}$ to $\frac{1}{4000}$ of an inch in diameter. Dissolves in dilute muriatic acid, with some flocculent deposit. Upon evaporation, star-like masses of crystals form. I look upon this specimen as of importance in helping to substantiate what I advance in relation to water and ice in producing the diamond deposit.

We have hitherto confined our attention to the locality known as the Diamond Fields, namely, De Beer's, Du Toits, &c.; but let us take a further stroll, in imagination, and see if we can follow the trail of the diamonds on their travels.

As we do not know their home, we cannot call there; we can only follow them after they have left it. Now, we know them at De Beer's, Klip Drift, and neighbouring places. Do they not extend down the river? have they not been found lower down? or are the reports only false? In the Cape Town Museum there is a small black velvet tray containing diamonds, six or eight in number, but very small, and bearing this label—"South African Diamonds." When I saw them, their history was unknown, whether recorded when received into the Museum only a search I presume could find out. When found, or where from, I could not learn, but there they are, and so labelled. Will it be assuming too much to suppose they were not found so far in the interior as the present diamond mines? I start this theory from having specimens of fine garnet sand from Namaqua Land, larger from the diggings, and large pieces from localities still further inland.

The question I would wish to put is, have the diamonds, in their removal by the river, been left in trails, if I may so speak, the large remaining behind, the smaller going forward with the sand &c. of a river bed? And if so, where will their travels terminate? When I landed in Algoa Bay some twenty years back, I was told of a diamond having been picked up on the beach. I paid no heed to the report, thinking it likely to have come out of a wrecked vessel. It now recurs to me, was it true? and had the diamond come from above the present diamond fields, passing them down the Orange River to the mouth, and then, from the action of the currents of the ocean, at last to find an owner on Algoa Bay beach?

In conclusion, I may observe that as I have simply put forward what I think are just conclusions, from what my opportunities have allowed me to observe, I shall be glad to be corrected, or assisted to learn more upon this very interesting subject.

ANNUAL GENERAL MEETING, February 6th, 1874.

Henry Woodward, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Report was read by the Honorary Secretary:—

REPORT OF THE GENERAL COMMITTEE FOR 1873.

In presenting their Report of the operations of the Geologists' Association during the year just closed, the General Committee have great pleasure in being able to offer their congratulations to the Members on the completion of another year of prosperity and progress.

While the number of new Members added to the Association has again been large, the withdrawals have been few, thus giving a great numerical increase during the year, as will be seen from the following statement:—

Members elected during 1873 . . .	57
Withdrawals 12 . Death 1 . .	13
Increase	44

The census of the Association on the 1st of January, 1874, gave the following results:—

Honorary Members	13
Life Members	40
Old Country Members	29
Members contributing 10s. annually .	227
	309

A large increase of Members during three years in succession is, your Committee consider, a fact of much significance, since it warrants the belief that a continuous and rapid growth of the Association and its means of usefulness may, with confidence, be expected in the future.

The increase of the income of the Association has been more than commensurate with the increase of Members, in consequence

of the number of Life Compositions paid during the last year. This attests the confidence placed in the stability of the Association, and in the value of its advantages.

The Life Compositions of the year 1873, added to those of the two preceding years, will give to your Committee a sum of £110 5s. to be invested for the future benefit of the Association.

It will be seen from the List of Papers read during the past year that communications of great scientific value and varied interest have been contributed, and that Authors of eminence have presented to the Association the results of their investigations. It is hoped that the Address with which the President inaugurated the Session 1873-74, may be followed annually by an opening discourse from the Chair.

The Excursions of the Association have been, with one or two exceptions, numerously attended by Members and their friends, who have had during the last year opportunities afforded them for studying in the field the following Formations:—

POST GLACIAL—Brighton, Crossness, Eastbourne.
GLACIAL DRIFT — Finchley, Hatfield.
LONDON CLAY (BASEMENT BED)—Hatfield.
WOOLWICH AND READING SERIES—Charlton, Hatfield, Plumstead.
THANET SANDS—Charlton.
CHALK—Brighton, Charlton, Beachy Head, Hatfield.
UPPER GREENSAND—Eastbourne.
GAULT—Eastbourne.
WEALDEN — Bexhill, St. Leonards.
PURBECK—Hartwell.
PORTLANDIAN—Hartwell.
KIMMERIDGE CLAY—Hartwell.
FOREST MARBLE—Tadmarton.
GREAT OOLITE—Broughton, Oxfordshire.
INFERIOR OOLITE—Banbury, Barford, Newbottle.
UPPER LIAS—Banbury, Adderbury.
MIDDLE LIAS—Banbury, Adderbury.
LOWER LIAS—Banbury.
KEUPER—Berrow, Tewkesbury.
BUNTER—Malvern, Broomsberrow.
PERMIAN—Howler's Heath.
OLD RED SANDSTONE—Ledbury, Stoke Edith.
LUDLOW—Ledbury, Stoke Edith.
WENLOCK—Colwell, Ledbury, Woolhope.
UPPER LLANDOVERY—Eastnor, Woolhope.
LINGULA FLAGS—Malverns.

Amongst the advantages to be derived from taking part in the Excursions of the Geologists' Association, must be mentioned the opportunity afforded for the inspection and study of the fossils of the localities visited, preserved in local museums and private collections, which Members are most kindly invited to visit and inspect.

During the year 1873, the following Museums and Collections were inspected :—

Mr. THOMAS BEESLEY'S Collection of the Fossils of the neighbourhood of Banbury.
The Museum of Eastbourne College.
The Caldecott Museum, Eastbourne.
Mr. ROPER'S Collection of Cretaceous Fossils.
Dr. OGIER WARD'S Collection of Eastbourne Fossils.
The Brighton Museum.
Mr. WILLETT'S Collection of Sussex Chalk Fossils.
Mr. THOMAS DAVIDSON'S Collection of Volcanic Minerals.
The Museum of Malvern College.
Dr. GRINDROD'S Museum of Palæozoic Fossils.
The Brighton Aquarium.

To the Directors of the several Excursions, your Committee offer your thanks for the important services they have rendered, and to the authorities of the British Museum, the Museum of Practical Geology, and the Museum of the Royal College of Surgeons, for their courteous permission to inspect the valuable collections of which they are the custodians.

The kindness and hospitality offered to Members attending the Excursions by residents in the localities visited demand the warmest acknowledgments of the Association, and your Committee have, therefore, great pleasure in tendering to the following generous friends of the Association your cordial thanks :—

Thomas Beesley, Esq., F.C.S., Banbury ; the Rev. E. S. Dewick, M.A., F.G.S., and F. C. S. Roper, Esq., F.L.S., F.G.S., Eastbourne ; Frank E. Houghton, Esq., C.E., Crossness ; the Rev. Reginald Hill, Broomsberrow ; Dr. Grindrod, F.L.S., F.G.S., &c., Malvern ; J. E. H. Peyton, Esq , F.G.S., F.R.A.S., St. Leonards ; Mrs. Parker, Brighton ; the Rev. W. S. Symonds, M.A., F.G.S., Pendock ; and the Vicar of Tewkesbury.

The Excursion Session of 1873 was distinguished by the copious reports of your visits which appeared in local newspapers. While

evincing the growing importance of your field meetings, the publicity thus given to your proceedings cannot fail to be not only beneficial to the Association itself, but contributory in no small degree to our great object, that of diffusing Geological knowledge.

The "Proceedings" have been regularly continued, and your Committee have great pleasure in finding that the revenue of the Association is now sufficient to enable so much extra matter to be published during the present year as will lessen to a minimum the interval between the reading and the publication of Papers.

Your Committee are happy in being able to assure you that the removal of your Library to the meeting-room of the Association has been followed by the best results, as may be seen from the following return :—

Books issued during	1871	52
,, ,,	1872	87
,, ,,	1873	168

When it is found that the issue of books has been very nearly doubled in one year, there can be but one opinion as to the beneficial character of the removal.

Though this most gratifying increase of the usefulness of the Library is greatly due to the cause above mentioned, your Committee feel assured that the assiduity and zeal of your Deputy Librarian, Mr. Coombs, has contributed not a little to the present very satisfactory state of the Library.

While accessions to the Library by donations have been numerous, important additions have been made by purchase, as shewn by the Treasurer's account. The Geological Survey Maps and Sections used during the Excursions have been added to the Library, and as these increase in number year by year a very valuable department of your Library will gradually acquire importance.

Your Committee are quite sure you will share their regret at the retirement of Arthur Bott, Esq., F.G.S., from the office he has so long filled. Mr. Bott, one of its earliest members, has served the Association in the office of Honorary Librarian for a period of eleven years. A gentleman who has been so long connected with this Association, and who has attended so assiduously to the duties of his office, deserves the best thanks of the Members.

It is with feelings of the sincerest regret that your Committee have to announce the resignation of your Honorary Secretary, J. Logan Lobley, Esq., F.G.S., who, during a period of three years, has devoted himself most indefatigably to the promotion of the best interests of the Association. A review of the progress of the Society under Mr. Lobley's auspices as Secretary sufficiently attests the advantages it has derived from his great energy, his uniform courtesy and kindness, and the zeal and industry he has shown in promoting its success on every occasion. He has, however, generously consented to give us his continued aid and assistance as Editor of the "Proceedings."

Your Committee have great pleasure in recommending as his successor, W. H. Hudleston, Esq., M.A., F.G.S., who, from his devotion to Geology and the collateral sciences, together with the interest he has displayed in the operations of the Association, will doubtless prove a most valuable officer.

The continued ill-health of Mr. Hislop, and his removal from London having necessitated his retirement from the offices of Treasurer and Trustee, the former has been filled by the appointment of S. R. Pattison, Esq., F.G.S., to the office of Treasurer to the Association, and the latter by that of Henry Woodward, Esq., F.R.S., who, with the Rev. Thomas Wiltshire, M.A., F.G.S., and Arthur Bott, Esq., F.G.S., are the present Trustees of the Association.

Your Committee again desire to offer your best thanks to the authorities of University College for the privilege you enjoy of meeting in this beautiful Hall, as well as for the courtesy with which the wishes of the Committee are acceded to.

The following Papers were read during the year 1873 :—

On the Cambrian and Silurian Rocks of Ramsey Island, St. David's, by Dr. Henry Hicks, F.G.S.

On the Diprionidæ of the Moffat Shale, by Charles Lapworth, Esq., F.G.S.

On the Geology of Brighton, Part I., by James Howell, Esq.

On the Origin and Present Position of the Diamonds of South Africa, by G. C. Cooper, Esq.

On the Valley of the Vézère (Dordogne), its Limestones, Caves, and Pre-Historic Remains, by Professor T. Rupert Jones, F.R.S.

On Ammonite Zones in the Isle of Thanet, by Francis Alfred Bedwell, Esq., M.A., F.R.M.S.

A Sketch of the Geology of Northamptonshire, by Samuel Sharp, Esq., F.S.A., F.G.S.

On some New Crag Fossils, by ALFRED BELL, Esq.

An Account of the Eruption of Mount Vesuvius of April 1872, by J. M. BLACK, Esq.

The Opening Address of the Session 1873-74, by the President, HENRY WOODWARD, Esq., F.R.S., F.G.S., &c.

On the Yorkshire Oolites, by WILFRID H. HUDLESTON, Esq., M.A., F.G.S., &c.

The following is a list of the Excursions of 1873:—

	Directors.
Visit to the British Museum, March 27th.	William Carruthers, Esq., F.R.S., F.G.S.
Visit to the Museum of the Royal College of Surgeons, April 3rd.	Professor Flower, F.R.S., F.G.S. Professor Morris, F.G.S.
Excursion to Banbury, Oxfordshire, April 14th and 15th.	Professor Morris, F.G.S. Thomas Beesley, Esq., F.C.S.
Visit to the Museum of Practical Geology, April 21st.	Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S.
Excursion to Charlton, April 26th.	Professor Morris, F.G.S.
Excursion to Aylesbury, Buckinghamshire, May 5th.	Professor Morris, F.G.S.
Excursion to Eastbourne and St. Leonards, May 23rd and 24th.	The Rev. E. S. Dewick, M.A., F.G.S. John Hopkinson, Esq., F.G.S. J. E. H. Peyton, Esq., F.G.S.
Excursion to Finchley, May 31st.	Henry Walker, Esq., F.G.S.
Excursion to Brighton, June 11th.	The President, H. Woodward, Esq., F.R.S. Professor T. Rupert Jones, F.R.S.
Excursion to Hatfield, Herts, June 28th.	J. Logan Lobley, Esq., F.G.S.
Excursion to Plumstead and Crossness, July 5th.	Henry Walker, Esq., F.G.S. Frank E. Houghton, Esq., C.E.
Excursion to the Malvern District, July 21st, 22nd, 23rd, 24th, 25th, and 26th.	Dr. Grindrod, F.L.S., F.G.S. Rev. W. S. Symonds, M.A., F.G.S. Rev. R. Dixon, M.A., LL.M., F.G.S.

Your Committee beg to recommend the following List of Officers for the year 1874:—

PRESIDENT.

Henry Woodward, Esq., F.R.S., F.G.S., F.Z.S., &c.

VICE-PRESIDENTS.

Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S., &c.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Professor John Morris, F.G.S., &c.
The Rev. Thomas Wiltshire, M.A., F.G.S., F.L.S., &c.

TREASURER.

Samuel Rowles Pattison, Esq., F.G.S., 50, Lombard-street, E.C.

GENERAL COMMITTEE.

F. A. Bedwell, Esq., M.A., F.R.M.S.
Arthur Bott, Esq., F.G.S.
John A. Coombs, Esq., F.G.S.
Robert Etheridge, Esq., F.R.S., &c.
John Foulerton, Esq., M.D., F.R.S.E.
John Hopkinson, Esq., F.G.S.
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George Potter, Esq., F.R.M.S.
James Thorne, Esq., F.S.A.
Henry Walker, Esq., F.G.S.
The Rev. T. Wiltshire, M.A., F.G.S., F.L.S., &c.
Henry Woodward, Esq., F.R.S., &c.

HONORARY SECRETARY.

Wilfrid H. Hudleston, Esq., M.A., F.G.S., &c., 23, Cheyne Walk, S.W.

HONORARY LIBRARIAN.

John A. Coombs, Esq., F.G.S.

The Report was unanimously adopted, and the gentlemen therein recommended were duly elected Officers of the Association for the year 1874.

The thanks of the Association were given to the President, to the other Officers of the past year, and to the Auditors, for their services, and the Annual General Meeting then terminated.

[*The Treasurer's Account is on the next page.*]

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1873.

Dr.	£	s.	d.	Cr.	£	s.	d.
By Balance, January 1st, 1873	122	1	3	To Printing "Proceedings"	85	9	1
,, Annual Subscriptions and Admission Fees ...	122	16	0	,, Miscellaneous Printing	21	10	5
,, Life Compositions	63	0	0	,, Library	28	10	5
,, Sale of Publications	2	4	0	,, Gas and Attendance	6	7	6
,, Dividends on £126 16s. 4d. Consols	3	16	0	,, Postage, Stationery, Porterage, Advertising, &c.	35	13	7
				Balance	136	6	3
	£313	17	3		£313	17	3

We have this day examined the Accounts of the Geologists' Association, and we find that, according to the accounts laid before us, a sum of £11 16s. 8d. remained in the hands of the Treasurer on the 31st December, 1873, and a sum of £124 9s. 7d. in the hands of the late Treasurer, at the same date, making together a balance of £136 6s. 3d. due to the Association on the 31st December, 1873.

January 21st, 1874.

F. A. BEDWELL,
F. G. H. PRICE, } *Auditors.*

G. P. BACON, PRINTER, LEWES

INDEX.

	PAGE.
Acidified rain	259
Adderbury	204
Address, Opening, Session 1873-74, H. Woodward ...	i.
Agassiz, Prof., on Glacial action in S. America ...	xii.
Alberbury	144, 147
Alwalton Marble	249
Ammonites Lewisiensis ...	231
Ammonites of the Chalk ...	225
,, of Margate, discovery of ...	220
,, size of ...	231
Ammonites peramplus ...	231
Ammonite Zones in the Isle of Thanet, F.A. Bedwell...	217
Analysis of dark blue Magnetic Ore ...	305
,, Millepore Rock ...	308
Annual General Meeting, 1873	157
,, ,, 1874	344
Annual Report for 1872 ...	157
,, ,, 1873 ...	344
Aquarium, Brighton, visit to	240
Archæopteryx	xx.
Arenig Rocks	105, 156
Argyll, Duke of, on Glacial action	xii.
Ashburnham Beds ...	213
Ashdown Sand	213
Asmanite	v.
Atrio del Cavallo	254
Aves in Cambridge Greensand	8
Aylesbury, excursion to ...	210
Aylesford, Sands at ...	42
Aymestry Limestone	124, 152, 275
Backbury Hill	276
Bala Group	105
Balance Sheet, 1872 ...	164
,, 1873 ...	351
Banbury, conversazione at	199
,, excursion to ...	197
Bargate Stone	94
Barnack Rag	249
Basement bed of London Clay	151
Bath, excursion to ...	89
Battersea, recently exposed sections at, J. A. Coombs	33
Bay of Naples	262
Beachy Head	212
Bedwell, F. A., Ammonite zones in the Isle of Thanet	217
Beesley, T.	197
Bell, A., New Crag Fossils...	265
,, Corbicula fluminalis	117
Bensted, W. H.	38
Berrow	272
Better Bed Coal	xv.
Bexhill	214
Birds, fossil	xx.
Bischoff's experiments ..	15
Black, J. M., eruption of Mount Vesuvius ...	253
Black Shales	280
Bloxham	203
Bone Bed	124, 127
Bonney, Rev. T. G., Upper Greensand of Cambridgeshire	1
Borrowdale Series ...	108
Botanical department of British Museum, visit to	189
Boulder Clay ...	65, 215
Brachiopoda in Cambridge Greensand	ii.
Breitenbach Meteorite ...	v.
Brighton Chalk	196
,, Excursion to ...	239
,, Geology of, J. Howell	168
Raised beach pebbles, origin of ...	178
British Museum, visit to ...	86
,, Botanical department, visit to ...	189
Broadstairs Chalk ...	196
Bromley and Chislehurst, excursion to	114
Broughton Church and Castle	201
Bull Head Bed	84
Bunter	143, 278
Burrington	125
Busti Aerolite	v.
Caldecott Museum ...	212
Californian Flora... ..	xvi.
Cam river	2
Cambrians	125, 127

	PAGE.
Cambrians, St. David's, section of ...	102
Cambrian and Silurian rocks, classification of, H. Hicks	99
,, Ramsey Island, H. Hicks	155
Cambridge	2
Cambridge Greensand, age of	19
,, ,, aves in	8
,, ,, erratics	19
,, district physical geography of ...	17
Camden Park caves ...	115
Campbell, J., Hendon ...	115
Carruthers, W.	xv.
,, on Botanical department, British Museum ...	189
Castle Howard	322
Caves, Camden Park ...	115
,, Dordogne	208
Cave Man	208
Cephalopoda, Cambridge Greensand	10
Cetiosaurus humero-cristatus	xxi.
Chalk, Beachy Head ...	212
,, Broadstairs ...	196
,, Brighton	196
,, Guildford	93
,, Kent	225
,, Margate	217
,, ,, Fossils of...	194
,, ,, Minerals of	196
,, Norfolk	120
,, Watford	65
,, Works on the ...	238
,, Yarmouth	117
Chalk Marl	212
,, ,, Hunstanton ...	119
Chalk Period, duration of ...	224
Chalybeate Spring, Hampstead	24
Charles Museum, Maidstone	38
Charlton, excursion to ..	205
Child, Coles	114
Child's Hill, fossils from ...	23
Chillesford Series... ...	122
Chilworth and Guildford, excursion to	93
Chislehurst and Bromley, excursion to	114
Chlamydosaurus Kingii ...	xxii.
Church Stretton	126
Clarke, H., Influence of geological reasoning ...	129
Classification of the Cambrian and Silurian Rocks, H. Hicks	99
Claverton Down	92
Clencher's Mill	272
Cloughton Wyke	311
Coal	xv.
,, Measures, North Wales border	138
Coal Seams in the Permian at Ifton, D. C. Davies	138
Cœlenterata in Cambridge Greensand	12
Collyweston Slate... ...	246
Columnar Basalts, J. Curry	80
Colwell	277
Combe Mill, Barford ...	203
Cone of Vesuvius	262
Conglomerate of Miss Phillips	270
Conifers	190
Coniston Flags	112
,, Grits	113
,, Limestone ...	110
Conversazione, Banbury ...	199
,, ,, Malvern ...	278
Coombe rock, Brighton ...	184
Coombs, J. A.	169
,, recently exposed section at Battersea	33
Cooper, G. C., origin and present position of the diamonds of South Africa	192, 336
Coprolites in Cambridge Greensand	13
Corbicula fluminalis, its associates and distribution in Britain, A. Bell ...	117
Cornbrash ... 251,	292, 319
Cornstones	270
Cotham Marble	90
Coutts, Lady Burdett, collection, visit to ...	68
Crag	122
Crambeck Limestone ...	326
Crater of Vesuvius ...	263
Crayford and Erith, excursion to	83
Crossness, excursion to ...	265
,, Well-boring at ...	268
Crowstones	318
Crustacea in Cambridge Greensand	11
Cryptogams	189
Curry, J., Columnar Basalts	80
Daintree, R.	123
Darwin, C. ... xxiii.,	136
Dasornis Londonensis ...	xx.
Davidson, T. ... xviii.,	240
Davies, D. C., Coal seams in the Permian at Ifton ...	138
Deans of Sussex	169
Deinosauria in Cambridge Greensand	8
Derwent Valley section ...	321, 323
Dewick, Rev. E. S. ...	211
Dunstone	125
Diamond Fields of S. Africa, J. Paterson	70
,, extent of ...	70, 79
,, physical features of...	70
Diamonds, probable origin of	78

	PAGE.
Diamonds of S. Africa, abundance of ...	79
,, occurrence of ...	78
,, origin and present position of, G. C. Cooper	192
Dip of Chalk in Norfolk, and remains of old land surfaces called the Stone bed, J. Gunn	117
Diprionidæ of the Moffat Shale, C. Lapworth ...	165
Diprotodon	86
Dixon, Rev. R.	269
Dogger, the	291, 293
Donations, 1, 21, 42, 70, 99, 116, 128, 138, 155, 165, 168, 191, 206, 216, 242, 281, 283, 335	
Dormington	276
Downton	125
,, Sandstone ...	127
Dromornis	xix.
Dufton Shales	109
Dumfriesshire, Llandeilo of	111
Eastbourne and St. Leonards, excursion to	211
Eastnor	270, 280
Echinodermata in Cambridge Greensand	11
Elections, 21, 42, 70, 99, 117, 128, 138, 155, 165, 168, 192, 207, 217, 243, 282, 283, 335	
Elephant bed, Brighton ...	184, 239
Englefield, Sir H.... ...	180
Erith and Crayford, excursion to	83
Eruption of Mount Vesuvius, J. M. Black	253
Esk Valley	289
Etheridge, R.	205
Ethnology	137
Evans, C. ... 67, 116,	216, 219
,, geology of Hampstead	21
,, well section at Finchley	148
Evolution	xxiii.
Excursions, 1872	158, 162
,, 1873	349
Excursion to Aylesbury ...	210
,, Banbury ...	197
,, Bath... ...	89
,, Brighton ...	239
,, Bromley and Chislehurst...	114
,, Charlton ...	205
,, Eastbourne and St. Leonards	211
,, Erith and Crayford ...	83
,, Finchley ...	214
,, Guildford and Chilworth ...	93
,, Hampstead ...	67
,, Hatfield ...	240
,, Hendon and Finchley ...	115
Excursion to Ludlow and the Longmynds	124
,, Maidstone ...	38
,, Malvern ...	269
,, Plumpstead & Crossness ...	265
,, Walton-on-the Naze ...	122
,, Watford ...	65
Excavations on the site of Law Courts, W. H. Hudleston	43
Fairlight Clays	213
Ferns	189
Finchley	30
,, excursion to ...	214
,, well section at, C. Evans	148
,, and Hendon, excursion to	115
Fleet River, source of ...	24
Flight, Dr.	iv.
Flint band, remarkable, Isle of Thanet	226
Flower, Prof.	190
Foraminifera in Cambridge Greensand	12
Forest bed of Thames Valley	266
Formation of Mountain Chains	vii.
Formations and localities inspected, 1872	158
,, 1873	345
,, in Northamptonshire, thickness of	252
Fossil collecting	234
Fossils from Black Shales, Malvern ...	210, 280
,, Chalk, Margate J. W. Wetherell	192, 194
,, Cornbrash, Scarborough ...	319
,, Dogger, Yorkshire ...	300
,, Great Oolite, Banbury ...	200, 201
,, Great Oolite, Northamptonshire ...	249
,, Inferior Oolite, Coombe Hill	203
,, Inferior Oolite, Northamptonshire ...	244, 248
,, Kimmeridge Clay, Aylesbury ...	210
,, Lias, Banbury...	198
,, ,, Northamptonshire	244
,, London Clay, Battersea ...	37
,, ,, Child's Hill	23
,, ,, Finchley ...	152
,, ,, site of Law Courts ...	60, 64

	PAGE.
Mountains	vii.
Murchison, Sir R.... 144,	181, 275
,, classification of the Cambrian and Silurian rocks ...	100
Museum, visit to Bath ...	89
,, ,, Brighton...	240
,, ,, Caldicott...	212
,, ,, Eastbourne College...	211
,, ,, Grindrod...	269
,, ,, Malvern College...	279
,, ,, Practical Geology	38, 205
,, ,, Royal College of Surgeons	190
Museums visited, 1872 ...	159
,, ,, 1873 ...	346
Muswell Hill	215
Nature and formation of flint and allied bodies, M. H. Johnson	335
Neolimulus	xviii.
New Crag fossils, A. Bell ...	265
Newbottle	199
Newbridge Hill, Bath ...	90
New Rush diggings ...	338
Nicholson, Prof.	168
,, Silurian rocks of English Lake District ...	105
Nordenskiold, Prof. ...	xii.
Norfolk, Geology of ...	119
Northampton Sands ...	199, 244
Northamptonshire, Geology of, S. Sharp	243
Norwood Hills	26, 32
Odontopteryx toliapicus ...	xxi.
Officers for 1873	163
,, 1874	349
Old Red	270, 275
Old Roar...	213
Oldhamite	v.
Onney Valley	126
Opening address of Session, 1873-74	i, 282
Origin and present position of the diamonds of South Africa, G. C. Cooper ...	192, 336
Osbornite	v.
Owen, Prof.	xviii., 86
Oxford Clay	251
Palæontographical Society	xvii.
Palæontology	ii., xiv.
,, influence of ...	121
Palæophytology	ii., xiv.
Palæozoology	ii., xvii.
Papers read, 1872	158, 161
,, 1873	348
Parker, J. ...	127, 272, 274
Passage beds	275
Paterson, J.	336
,, Diamond fields of South Africa ...	70
Pattison, S. R.	67
Pegwell Bay	223
Pendock	272, 274
Permian basement beds ...	144
,, coal seams, D. C. Davies	138
Perry, Captain	268
Perton	275
Petrology	ii.
Peyton, J. E. H.	211, 213
Phascolomys	xix.
Phillips, Prof.	xxi.
Phosphatic nodules, composition of	6
,, ,, formation of	15, 16
Phosphate of lime, solubility of	15
Physical conditions, Lower Eocene	27
Physical geology	vi.
Pilgrims' Way, Kent ...	40
Pisces in Cambridge Greensand	9
Plant, J.	273, 277
Pleistocene at Erith ...	85
Pleurotoma varicosa ...	64
Plumstead and Crossness, excursion to	265
Portland stone and sands ...	210
Post pliocene brick earth of Brighton	181
Pre-Cambrian Rocks of Britain	101
Prestwich, Mr.	26, 28
Proceedings of Geologists' Association, 1873 ...	334
Pterodactyles in Cambridge Greensand	8
Ptychodus latissimus from Chalk of Grays, O. Rees...	117
Pull Court	274
Purbeck Beds	211
Queensland minerals ...	123
Ragged Stone Hill ...	272, 273
Ramsey Island	155
Reading Beds	241
Recent deposits, Brighton...	175
Recently exposed section at Battersea, J. A. Combs ...	33
Red Crag, fauna of ...	123
,, Walton-on-the-Naze	122
Rees, O., Ptychodus latissimus from Chalk of Grays	117
Reliquiæ Aquitanicæ ...	210
Report, Annual, 1872 ...	157
,, 1873 ...	344
Rhœtic Beds	91
Rocky Mountains ...	xiii.
St. Catherine's Hill, Guildford	94
St. David's, section of Cambrian Rocks at ...	102

	PAGE.
St. Leonards, excursion to	213
St. Martha's Hill... ...	95
Salter, J., diagrams by ...	277
Salway, H.	125
Scarborough Limestone ...	292, 311
Scuterdine	277
Section, Battersea ...	34
,, Blue Wyke Bay ...	294
,, Broughton ...	201
,, Crag Hall ...	303
,, Crossness ...	266, 269
,, Danholm	310
,, Derwent Valley ...	323
,, Dundas	92
,, Finchley	149
,, Hatfield	241
,, Hundale	312
,, Ifton	140
,, Kentish Town ...	22
,, King's Sutton ...	198
,, Law Courts site ...	46
,, Margate	193, 225
,, St. David's ...	102
,, Seamer	287
,, Thanet Sands ...	85
,, Vale of Pickering ...	290
,, White Nab ...	315
,, Yarmouth to Hunstanton ...	118
,, Yorkshire coast ...	321
Sedgwick, Prof., classification of the Cambrian and Silurian rocks	100
Seeley, H.	5, 8, 20
,, formation of phosphatic nodules...	16
Sequoia trees	xvi.
Serpentine, source of the ...	24
Sharp, S., geology of Northamptonshire	248
Shortlands, Kent, well at ...	114
Shelve	126
Stucknell Hill	276
Silurian rocks of Lake District, H. A. Nicholson ...	105
Silurian, Upper, thickness of	113
Skiddaw Slates	106
Smith, Rev. I. G. ...	279
Source of Northamptonshire rivers	252
South Africa, diamond fields of, J. Paterson	70
South Downs	239
South Kensington Museum, gems at	123
Spongida in Cambridge Greensand	12
Stiperstones	126
Stoke Edith	275
Stokesay Castle	127
Stone	211
Stone Bed of Norfolk ...	119
Striatulus beds	295
Strophomena Shales ...	110
Struthions birds ...	xix.
Subsidence near Ryde ...	180
Sub-Wealden exploration ...	97
Sun bed	91
Sundridge Park	114
Sussex coast line, recent modifications of ...	172
Sweeney Mountain ...	139
Swindale Shales	109
Symonds, Rev. W. S. ...	269
Tadmarton	202
Teme-river	124
Tennant, Prof.	88, 123
Tewkesbury	272
Thanet Sands	206
,, ,, Erith ...	83
Thames, origin of ...	267
Thames Valley forest bed ...	266
,, gravel	33, 44, 52, 62
Tremadoc Rocks	104, 156
Trinucleus Shales ...	110
Tunbridge Wells Sands ...	213
Upper Greensand	213
,, thickness of...	18
,, or Chloritic Marl of Cambridgeshire, Rev. T G. Bonney ...	1
Upper Ludlow	124, 127
Upper Silurians, thickness of	143
Vale of Clwyd	143
Vale of Pickering	284
Vesuvian vineyards ...	260
Vézère, valley of, its limestones, caves, and prehistoric remains, Prof. T. Rupert Jones	207
Visit to British Museum ...	86, 189
,, Grindrod Museum	269
,, International Exhibition	123
,, Museum of Malvern College... ...	279
,, ,, of Practical Geology...	88, 205
,, ,, of Royal College of Surgeons ...	190
Volcanic ash	258
Völcker, Dr., analysis of phosphatic nodules ...	6
Wadhurst Clay	213
Walker, H. ...	150, 214, 265
Walton-on-the-Naze, excursion to...	122
Warley Valley	91
Waterstones	273
Watford, excursion to ...	65
Weald, denudation of ...	239
,, lateral valleys of ...	40
Wealden...	213
Weldon Stone	248
Well section at Finchley, C. Evans	148

	PAGE.
Wells at Erith	83
Wenlock	125, 271, 276
Wetherell, J. W. some fossils from the Margate Chalk...	192
Whirlwind near Banbury ..	199
White Lias	90
Whitaker, W., 25, 65, 84, 148, 241, 265	
,, on denudation of the Chalk ...	230
Whitwell Limestone ...	326
Widmore, Kent ...	114
Wiltshire, Rev. T. ...	xvii., 160
Winwood, Rev. H. H. ...	89
Wombats...	xix.
Wood, S. V. ...	xviii., 266
Woodward, H. ...	86, 160, 239, 282
Woodward, H., opening address of Session, 1873-74...	i.
Woolhope Limestone ...	276, 277
,, valley	275
Woolwich Beds	114, 206
,, ,, Bushey ...	67
,, ,, Finchley ...	153
,, ,, Guildford ...	93
Worcestershire Beacon ...	270, 279
Wrexham	143
Wright, Dr.	91, 316
Wyche, the	277
Yarmouth to Hunstanton section	118
Yorkshire Oolites, W. H. Hudleston	283
Zone of Life theory ...	220, 233

550
G4i